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# CHEMISTRY today

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# PRACTICE PAPER

# NEET

Exam on
13th September 2020

1. Which of the following diols would cleave into two equal fragments with $HIO_4$?
   (a) 1,3-Hexanediol (b) 2,4-Hexanediol
   (c) 1,6-Hexanediol (d) 3,4-Hexanediol

2. Artificial sweetener which is stable under cold conditions only is
   (a) saccharin (b) sucralose
   (c) aspartame (d) alitame.

3. (I) $H_2O_2 + O_3 \longrightarrow H_2O + 2O_2$
   (II) $H_2O_2 + Ag_2O \longrightarrow 2Ag + H_2O + O_2$
   Role of hydrogen peroxide in the above reactions is respectively
   (a) oxidising in (I) and reducing in (II)
   (b) reducing in (I) and oxidising in (II)
   (c) reducing in (I) and (II)
   (d) oxidising in (I) and (II).

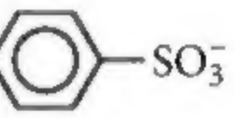
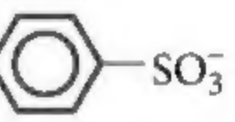
4. Which set of quantum numbers is possible for the last electron of $Mg^+$ ion?
   (a) $n = 3, l = 2, m = 0, s = +1/2$
   (b) $n = 2, l = 3, m = 0, s = +1/2$
   (c) $n = 1, l = 0, m = 0, s = +1/2$
   (d) $n = 3, l = 0, m = 0, s = +1/2$

5. Which of the following will have a *meso*-isomer?
   (a) 2-Chlorobutane
   (b) 2-Hydroxypropanoic acid
   (c) 2,3-Dichloropentane
   (d) 2,3-Dichlorobutane

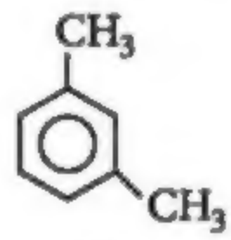
6. Which of the following reactions is said to be entropy driven?
   (a) Endothermic reaction with positive entropy change and high temperature
   (b) Endothermic reaction with negative entropy change and low temperature
   (c) Exothermic reaction with positive entropy change and high temperature
   (d) Exothermic reaction with negative entropy change and low temperature

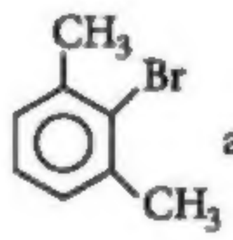
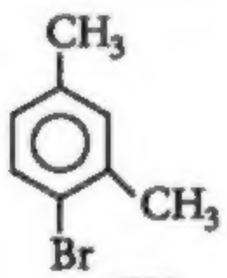
7. Which of the following does not liberate $O_2$ on heating?
   (a) MgO (b) $NaNO_3$
   (c) $Pb_3O_4$ (d) $KClO_3$

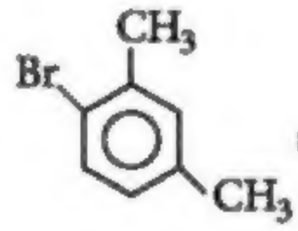
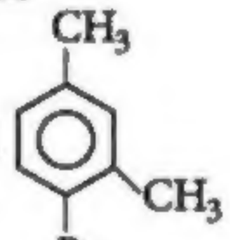
8. If $10^{21}$ molecules are removed from 200 mg of $CO_2$, the number of moles of $CO_2$ left is
   (a) $2.88 \times 10^{-3}$ (b) $28.8 \times 10^{-3}$
   (c) $0.288 \times 10^{-3}$ (d) $1.66 \times 10^{-2}$

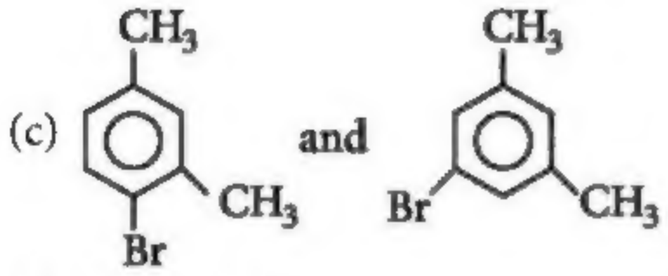
9. Leaving tendency of the following groups in decreasing order is
   I. $Cl^-$ II. 
   III. $OH^-$ IV. 
   (a) IV > II > I > III (b) I > II > III > IV
   (c) II > IV > I > III (d) I > IV > II > III.

10. What products are formed when the following compound is treated with $Br_2$ in the presence of $FeBr_3$?



(a)  and 

(b)  and 

(c)  and 

(d) None of these

**11.** The ions $O^{2-}$, $F^-$, $Na^+$, $Mg^{2+}$ and $Al^{3+}$ are isoelectronic. Their ionic radii show
(a) a decrease from $O^{2-}$ to $F^-$ and then increase from $Na^+$ to $Al^{3+}$
(b) a significant increase from $O^{2-}$ to $Al^{3+}$
(c) a significant decrease from $O^{2-}$ to $Al^{3+}$
(d) an increase from $O^{2-}$ to $F^-$ and then decrease from $Na^+$ to $Al^{3+}$.

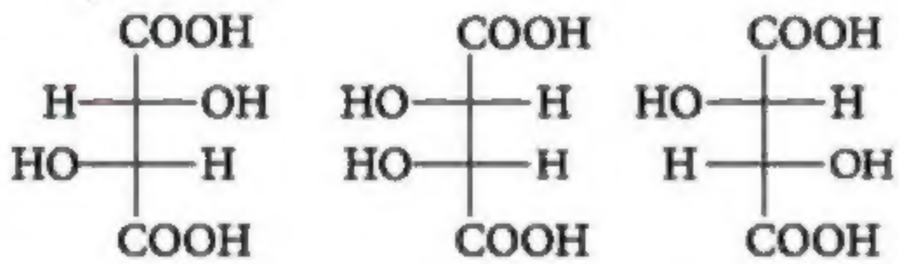
**12.** Acidity of diprotic acids in aqueous solutions increases in the order
(a) $H_2S < H_2Se < H_2Te$ (b) $H_2Se < H_2S < H_2Te$
(c) $H_2Te < H_2S < H_2Se$ (d) $H_2Se < H_2Te < H_2S$

**13.** The correct order of increasing basicity of the given conjugate bases ($R = CH_3$) is
(a) $RCOO^- < HC \equiv C^- < NH_2^- < R^-$
(b) $RCOO^- < HC \equiv C^- < R^- < NH_2^-$
(c) $R^- < HC \equiv C^- < RCOO^- < NH_2^-$
(d) $RCOO^- < NH_2^- < HC \equiv C^- < R^-$

**14.** The pH of 0.004 M hydrazine solution is 9.7. Its ionisation constant ($K_b$) is
(a) $7.79 \times 10^{-8}$ (b) $4.49 \times 10^{-9}$
(c) $1.67 \times 10^{-10}$ (d) $6.25 \times 10^{-7}$

**15.** The vapour density of a mixture containing $NO_2$ and $N_2O_4$ is 38.3 at 300 K. The number of moles of $NO_2$ in 100 g of the mixture is approximately
(a) 0.44 (b) 4.4 (c) 33.4 (d) 3.34

**16.** Pair of enantiomers from the following compounds are



(I) (II) (III)

(a) I and II (b) II and III
(c) I and III (d) both (a) and (b).

**17.** In a face centred cubic arrangement of *A* and *B* atoms, *A* atoms are at the corners of the unit cell and *B* atoms at the face centres. One of the *A* atoms is missing from one corner in the unit cell. The simplest formula of the compound is
(a) $A_7B_3$ (b) $AB_3$
(c) $A_7B_{24}$ (d) $A_{7/8}B_5$

**18.** Among the following mixtures, dipole-dipole as the major interaction is present in
(a) benzene and ethanol
(b) acetonitrile and acetone
(c) KCl and water
(d) benzene and carbon tetrachloride.

**19.** One mole of a complex compound $Co(NH_3)_5Cl_3$ gives 3 moles of ions when dissolved in water. One mole of the same complex reacts with two moles of $AgNO_3$ solution to form two moles of AgCl. The structure of complex is
(a) $[Co(NH_3)_5Cl]Cl_2$
(b) $[Co(NH_3)_3Cl_3].2NH_3$
(c) $[Co(NH_3)_4Cl_2]Cl.NH_3$
(d) none of these.

**20.** The energy absorbed by each molecule ($A_2$) of a substance is $4.4 \times 10^{-19}$ J and bond energy per molecule is $4.0 \times 10^{-19}$ J. The kinetic energy of the molecule per atom will be
(a) $2.2 \times 10^{-19}$ J (b) $2.0 \times 10^{-19}$ J
(c) $4.0 \times 10^{-20}$ J (d) $2.0 \times 10^{-20}$ J

**21.** An alkane $C_7H_{16}$ is produced by the reaction of lithium di(3-pentyl)cuprate with ethyl bromide. The name of the product is
(a) 3-methylhexane (b) 2-ethylpentane
(c) 3-ethylpentane (d) *n*-heptane.

**22.** Thermal decomposition method is used to purify
(a) Ni (b) Cr
(c) Sn (d) Pb

**23.** Which of the following synthesis gives 3-methyl-1-hexanol?
(a) 2-Bromohexane $\xrightarrow[C_2H_5OC_2H_5]{Mg}$ $\xrightarrow[(ii)\ H_3O^+]{(i)\ H_2C=O}$
(b) 2-Bromopentane $\xrightarrow[C_2H_5OC_2H_5]{Mg}$ $\xrightarrow[(ii)\ H_3O^+]{(i)\ \text{epoxide}}$
(c) 3-Bromopentane $\xrightarrow[C_2H_5OC_2H_5]{Mg}$ $\xrightarrow[(ii)\ H_3O^+]{(i)\ CH_3CH=O}$
(d) 1-Bromobutane $\xrightarrow[C_2H_5OC_2H_5]{Mg}$ $\xrightarrow[(ii)\ H_3O^+]{(i)\ CH_3COCH_3}$

**24.** Which of the following are isoelectronic and isostructural?

$NO_3^-$, $CO_3^{2-}$, $ClO_3^-$, $SO_3$

(a) $NO_3^-$, $ClO_3^-$ (b) $SO_3$, $NO_3^-$

(c) $CO_3^{2-}$, $SO_3$ (d) Both (b) and (c)

**25.** The enthalpy of neutralisation of $NH_4OH$ and $CH_3COOH$ is $-10.5$ kcal $mol^{-1}$ and enthalpy of neutralisation of $CH_3COOH$ with strong base is $-12.5$ kcal $mol^{-1}$. The enthalpy of ionisation of $NH_4OH$ will be

(a) 4.0 kcal $mol^{-1}$ (b) 3.0 kcal $mol^{-1}$

(c) 2.0 kcal $mol^{-1}$ (d) 3.2 kcal $mol^{-1}$

**26.** Which of the following is not the characteristic of interhalogen compounds?

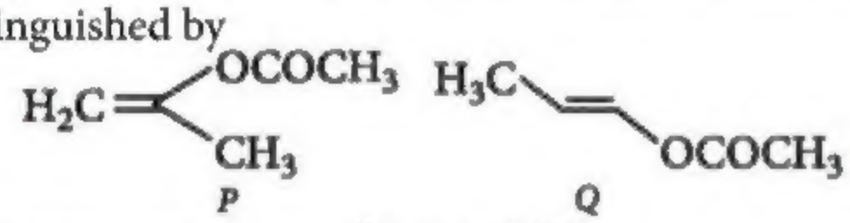
(a) They are more reactive than halogens.

(b) They are quite unstable but none of them is explosive.

(c) They are covalent in nature.

(d) They have low boiling points and are highly volatile.

**27.** The product of acid hydrolysis of *P* and *Q* can be distinguished by



*P* *Q*

(a) Lucas reagent (b) 2,4-DNP

(c) Fehling's solution (d) $NaHSO_3$

**28.** Which of the following orders is true regarding the basic nature of $NH_2$ group?

(a) *o*-Toluidine > Aniline > *o*-Nitroaniline

(b) *o*-Toluidine < Aniline > *o*-Nitroaniline

(c) *o*-Toluidine < Aniline < *o*-Nitroaniline

(d) *o*-Toluidine > Aniline < *o*-Nitroaniline

**29.** Schottky defect in crystals is observed when

(a) unequal number of cations and anions are missing from the lattice

(b) equal number of cations and anions are missing from the lattice

(c) anion leaves its normal site and occupies an interstitial site

(d) density of the crystal is increased.

**30.** The indicator that is obtained by coupling the diazonium salt of sulphanilic acid with *N*,*N*-dimethylaniline is

(a) phenanthroline (b) methyl orange

(c) methyl red (d) phenolphthalein.

**31.** Aqueous ammonia is used as a precipitating reagent for $Al^{3+}$ ions as $Al(OH)_3$ rather than aqueous NaOH, because

(a) $NH_4^+$ is a weak base

(b) NaOH is a very strong base

(c) NaOH forms $[Al(OH)_4]^-$ ions

(d) NaOH forms $[Al(OH)_2]^+$ ions.

**32.** The electronic configuration of actinoids cannot be assigned with degree of certainty because of

(a) small energy difference between 5*f* and 6*d* levels

(b) overlapping of inner orbitals

(c) free movement of electrons over all the orbitals

(d) none of the above.

**33.** If a solution containing components *A* and *B* follows Raoult's law then

(a) *A*—*B* attraction force is greater than *A*—*A* and *B*—*B*

(b) *A*—*B* attraction force is less than *A*—*A* and *B*—*B*

(c) *A*—*B* attraction force remains same as *A*—*A* and *B*—*B*

(d) volume of solution is different from sum of volumes of solute and solvent.

**34.** Fructose gives the silver mirror test because it

(a) contains an aldehyde group

(b) contains a keto group

(c) undergoes rearrangement under the alkaline conditions of the reagent to form a mixture of glucose and mannose

(d) none of these.

**35.** What happens when the temperature of a solution is increased from 25°C to 65°C ?

(a) The rate of the reaction remains unchanged and the rate constant *k* decreases.

(b) The rate of the reaction increases and rate constant *k* decreases.

(c) The rate of the reaction decreases and so does the rate constant *k*.

(d) The rate of the reaction increases and so does the rate constant *k*.

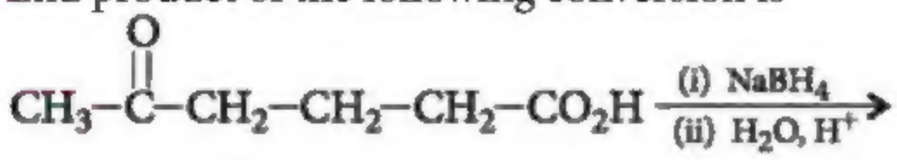
**36.** When $LiNO_3$ is heated, it gives oxide, $Li_2O$, whereas other alkali metal nitrates decompose to give corresponding

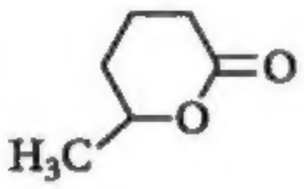
(a) nitrite (b) peroxide

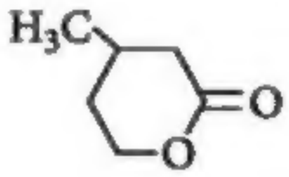
(c) both nitrite and oxide

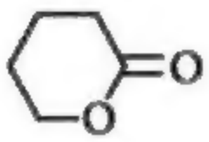
(d) none of these.

37. End product of the following conversion is



(a) 

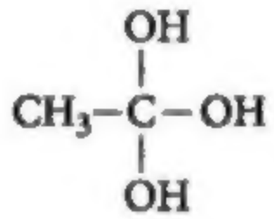
(b) 

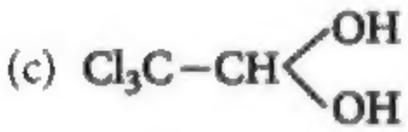
(c) 

(d) 

38. A compound containing two –OH groups attached with one carbon atom is unstable but which one of the following is stable?

(a) 

(b) 

(c) 

(d) None of these

39. Which one of the following statements is not true?
(a) pH of drinking water should be between 5.5 – 9.5.
(b) Concentration of DO below 6 ppm is good for the growth of fish.
(c) Clean water would have a BOD value of less than 5 ppm.
(d) Oxides of sulphur, nitrogen and carbon are the most widespread air pollutants.

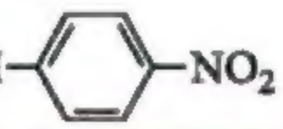
40. Beckmann rearrangement is involved in the synthesis of which of the following polymers?
(a) PAN (b) Nylon 6,10
(c) Nylon-6 (d) Melamine

41. Propanal on treatment with dilute sodium hydroxide forms
(a) $CH_3CH_2CH_2CH_2CH_2CHO$
(b) $CH_3CH_2CH(OH)CH_2CH_2CHO$
(c) $CH_3CH_2CH(OH)CH(CH_3)CHO$
(d) $CH_3CH_2COONa$

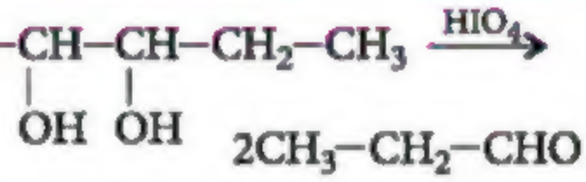
42. An explosion takes place when conc. $H_2SO_4$ is added to $KMnO_4$. Which of the following is formed?
(a) $Mn_2O_7$ (b) $MnO_2$
(c) $MnSO_4$ (d) $Mn_2O_3$

43. Which one of the following shows highest magnetic moment?
(a) $V^{3+}$ (b) $Cr^{3+}$ (c) $Fe^{3+}$ (d) $Co^{3+}$

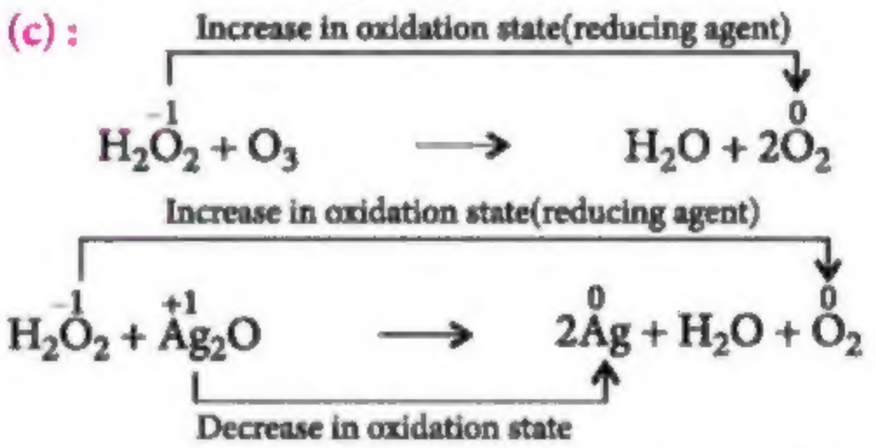
44. $R - OH + HX \rightarrow RX + H_2O$
In the above reaction, the reactivity of alcohols is
(a) tertiary > secondary > primary
(b) tertiary < secondary < primary
(c) tertiary > primary > secondary
(d) secondary > primary > tertiary

45. Which of the following is the least reactive compound towards nucleophilic acyl substitution?
(a) $CH_3COCl$
(b) $CH_3CONHCH_3$
(c) $CH_3CONHC_6H_5$
(d) 

## SOLUTIONS

1. **(d):** 

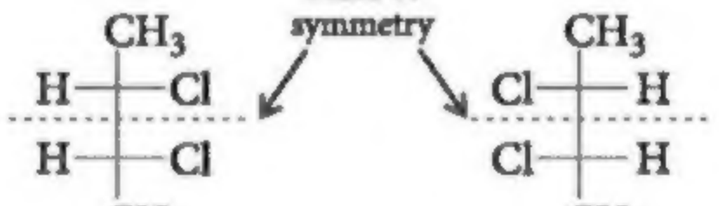
2. **(c) :** Aspartame is stable under cold conditions but unstable at cooking temperature.

3. **(c) :** 

$H_2O_2$ acts as reducing agent in all those reactions in which $O_2$ is evolved.

4. **(d):** Last electron of $Mg^+$ is $3s^1$.
Mg : $1s^2 2s^2 2p^6 3s^2$ ; $Mg^+$ : $1s^2 2s^2 2p^6 3s^1$
∴ For an $e^-$ in 3*s*-orbital, the quantum numbers would be : $n = 3, l = 0, m = 0, s = +1/2$.

5. **(d):** 2,3-dichlorobutane contains a plane of symmetry *i.e.*, the upper half of the molecule is the mirror image of the lower half. The rotation of one half of the molecule will therefore exactly counter balance the rotation of other half, causing the molecule to be optically inactive. Such an internally compensated molecule is said to be a *meso*-form.



**6. (a):** For endothermic reaction, $\Delta H$ = +ve. For reaction to be spontaneous, $\Delta S$ must be positive and also $T\Delta S$ must be greater than $\Delta H$ in magnitude. The reaction is then said to be entropy driven.

**7. (a):** $2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$

$2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2$

$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$

MgO being high melting oxide does not decompose on heating to liberate $O_2$.

**8. (a):** 200 mg $CO_2$ = 0.2 g $= \frac{0.2}{44}$ mol $= 0.00454$ mol

$= 4.54 \times 10^{-3}$ mol

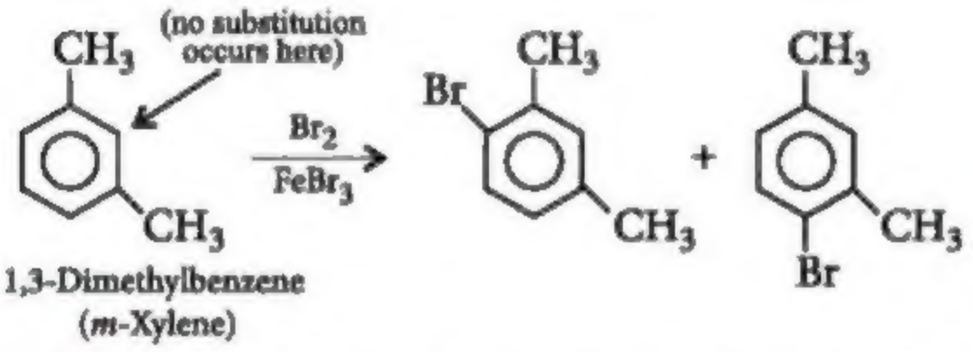
$10^{21}$ molecules of $CO_2 = \frac{10^{21}}{6.02 \times 10^{23}} = 1.66 \times 10^{-3}$ mol

$\therefore$ No. of moles left $= (4.54 - 1.66) \times 10^{-3}$

$= 2.88 \times 10^{-3}$

**9. (a):** As the negative charge of leaving group can be delocalised into the phenyl ring and if additionally attached group on the ring has $-I$ effect it will further delocalise the negative charge then such group has higher leaving tendency. Thus the leaving group activity order is so.

**10. (b):** $-CH_3$ group is *o,p*-directing. Because of crowding, no substitution occurs at the carbon atom between the two $-CH_3$ groups in *m*-xylene, even though two $-CH_3$ groups activate that position.




1,3-Dimethylbenzene
(*m*-Xylene)

**11. (c):** Ionic radii of isoelectronic ions decrease with increase of nuclear charge thus, it shows a decrease from $O^{2-}$ to $Al^{3+}$.

**12. (a):** As the atomic size increases down the group, the bond length increases and the bond strength decreases and the cleavage of *E*–H (*E* = S, Se, Te) bond becomes easier thus, more will be the acidity. Hence, the correct order is : $H_2S < H_2Se < H_2Te$.

**13. (a):** The order of basicity can be explained on the basis of the acidity of the acids of the given conjugate bases. Stronger the acid, weaker is the conjugate base. Since *R*COOH is the strongest acid amongst all, $RCOO^-$ is the weakest base. Due to *sp* hybridised carbon, acetylene is also acidic and hence, a weak base but stronger than $RCOO^-$. As $sp^3$ carbon is less electronegative than $sp^3$ nitrogen, $R^-$ is more basic than $NH_2^-$. So, the correct order is $RCOO^- < HC \equiv C^- < NH_2^- < R^-$.

**14. (d):** For weak bases :

$[OH^-] = \sqrt{K_b \times C}$

pH = 9.7 thus, pOH = 14 – 9.7 = 4.3

$-\log[OH^-] = 4.3$

$\Rightarrow [OH^-] = 5 \times 10^{-5}$

$5 \times 10^{-5} = \sqrt{K_b \times 0.004}$

or $K_b \times 0.004 = 25 \times 10^{-10}$

$\Rightarrow K_b = \frac{25}{4 \times 10^{-3}} \times 10^{-10} = 6.25 \times 10^{-7}$

**15. (a):** Molecular weight of the mixture $= 38.3 \times 2$

$= 76.6$

Let mass of $NO_2$ in the mixture = *x* g

then mass of $N_2O_4 = (100 - x)$ g

Number of moles of $NO_2 = x/46$

Number of moles of $N_2O_4 = \frac{100 - x}{92}$

(Molecular weight of $NO_2$ = 46, Molecular weight of $N_2O_4$ = 92)

$\frac{\text{Weight}}{\text{Number of moles}}$ = Molecular weight

$\frac{x + (100 - x)}{\frac{x}{46} + \frac{(100 - x)}{92}} = 76.6 \Rightarrow \frac{x}{46} + \frac{(100 - x)}{92} = \frac{100}{76.6}$

$x = 20.1$

Number of moles of $NO_2 = \frac{20.1}{46} = 0.437 \approx 0.44$

**16. (c):** Structures I and III are non-superimposable mirror images of each other. Hence, they are pair of enantiomers.

**17. (c):** One atom of (*A*) is missing from one corner.

No. of atoms *A* in unit cell $= 7 \times \frac{1}{8} = \frac{7}{8}$

No. of atoms *B* in unit cell $= 6 \times \frac{1}{2} = 3$

$A : B = \frac{7}{8} : 3$ so, simplest formula is $A_7B_{24}$.

**18. (b):** Dipole-dipole interactions occur among the polar molecules having permanent dipoles. The polarity of the molecules depends upon the electronegativities of the atoms present in the molecule and the geometry of the molecule.

| **Molecules** | **Interactions** |
|---|---|
| Benzene and ethanol | Dispersion forces |
| Acetonitrile and acetone | Dipole-dipole |
| KCl and water | Ion-dipole |
| Benzene and $CCl_4$ | Dispersion forces |

**19. (a) :** Since the complex gives two moles of AgCl, there must be two ionisable chlorine atoms. Hence, compound should be $[Co(NH_3)_5Cl]Cl_2$.

$$[Co(NH_3)_5Cl]Cl_2 + 2AgNO_3 \longrightarrow [Co(NH_3)_5Cl](NO_3)_2 + 2AgCl\downarrow$$

$$[Co(NH_3)_5Cl]Cl_2 \rightleftharpoons \underbrace{[Co(NH_3)_5Cl]^{2+} + 2Cl^-}_{\text{Three ions}}$$

**20. (d) :** Energy absorbed by each molecule $= 4.4 \times 10^{-19}$ J

Energy required to break the bond $= 4.0 \times 10^{-19}$ J

Remaining energy gets converted to kinetic energy

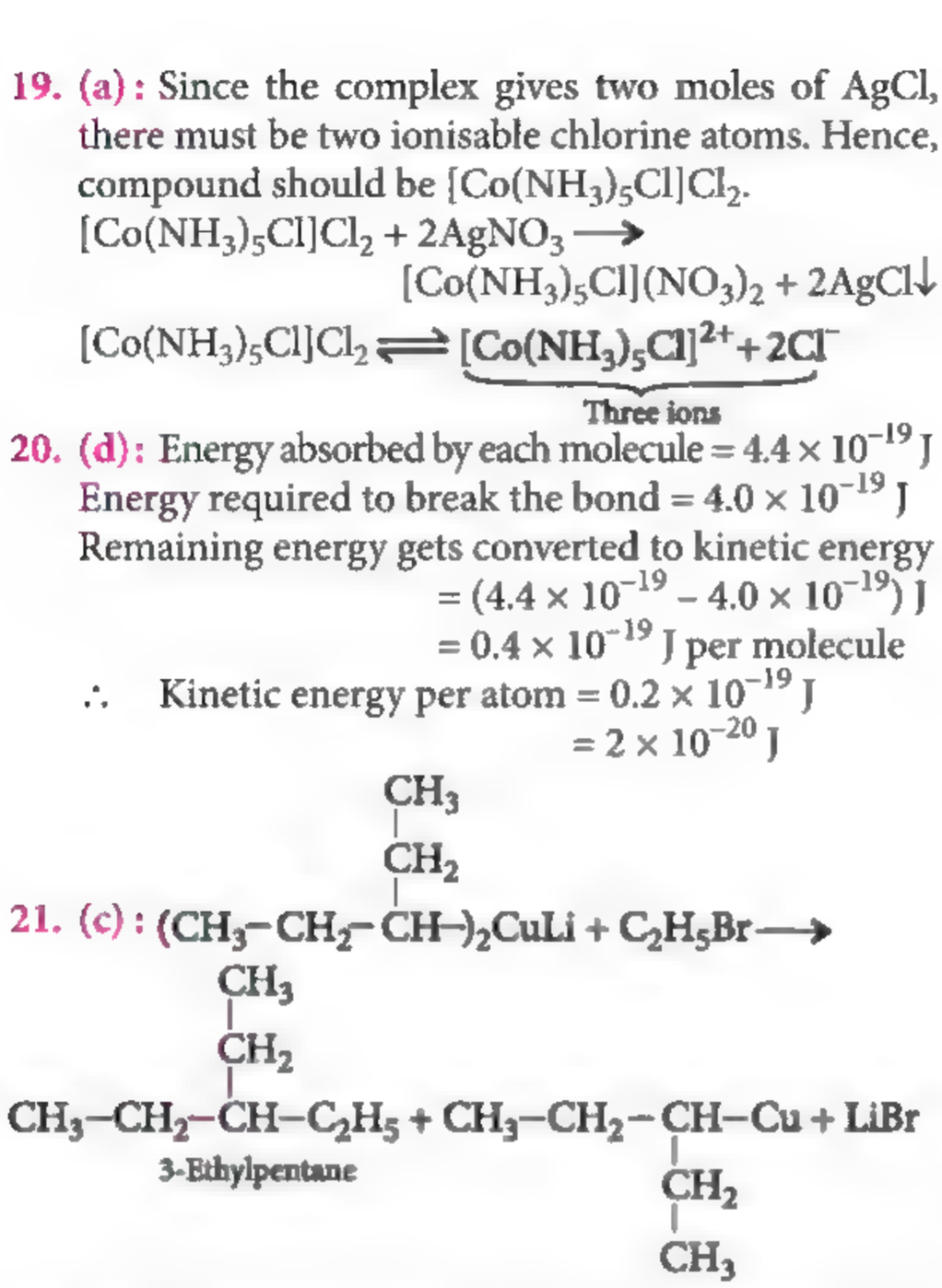
$= (4.4 \times 10^{-19} - 4.0 \times 10^{-19})$ J

$= 0.4 \times 10^{-19}$ J per molecule

$\therefore$ Kinetic energy per atom $= 0.2 \times 10^{-19}$ J

$= 2 \times 10^{-20}$ J

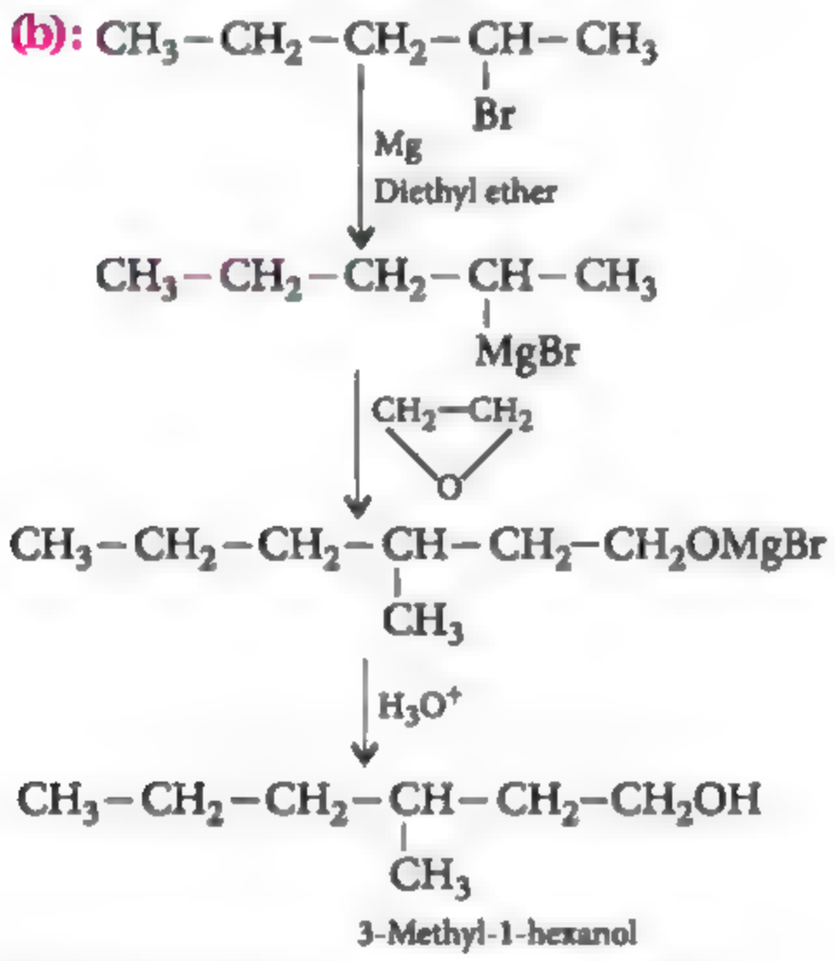
**21. (c) :**




**22. (a) :** Ni combines with CO at 323 K to form $Ni(CO)_4$ which decomposes thermally at 423 K to give pure Ni metal.

$$Ni(CO)_4 \xrightarrow{423\ K} Ni + 4CO\uparrow$$

**23. (b):**




**24. (d):** Total number of electrons in $NO_3^-$

$= (7 + 3 \times 8 + 1) = 32$

Total number of electrons in $CO_3^{2-}$

$= (6 + 3 \times 8 + 2) = 32$

Total number of electrons in $ClO_3^-$

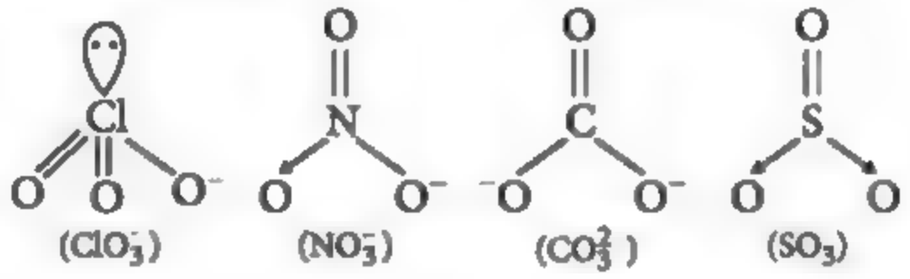
$= (17 + 3 \times 8 + 1) = 42$

Total number of electrons in $SO_3$

$= (16 + 3 \times 8) = 40$

Therefore, $NO_3^-$ and $CO_3^{2-}$ are isoelectronic.

Structures of given species can be represented as :




Thus, $NO_3^-$ and $CO_3^{2-}$ are isostructural and isoelectronic.

**25. (c) :** $\Delta H_{neut}$ for a strong acid with a strong base

$= -13.7$ kcal equiv$^{-1}$

$= -13.7$ kcal mol$^{-1}$

(For monovalent acids and bases)

$\Delta H_{ion}(CH_3COOH) = -12.5 - (-13.7)$

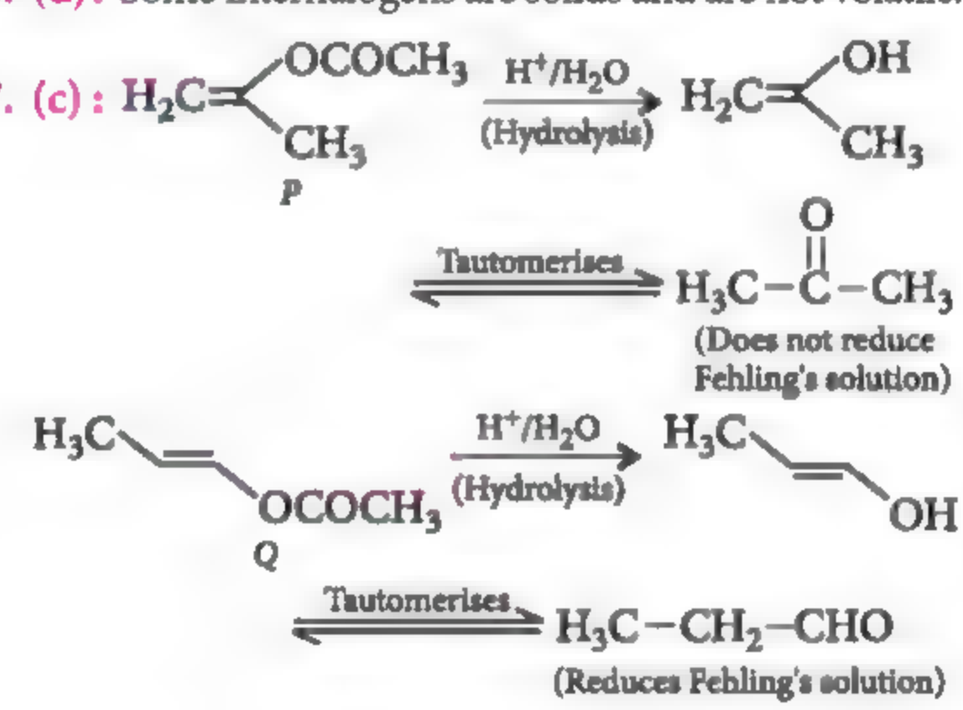
$= +1.2$ kcal mol$^{-1}$

$\Delta H_{ion}(NH_4OH) = -10.5 - (-13.7) - \Delta H_{ion}(CH_3COOH)$

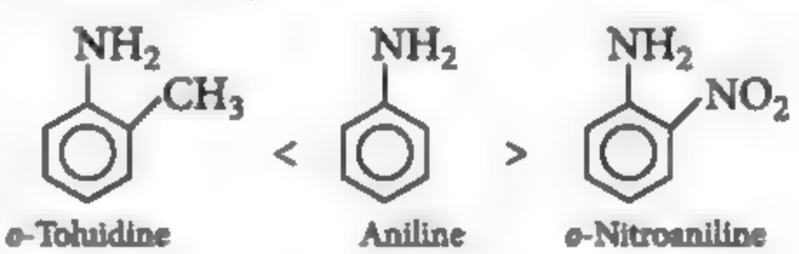
$= 13.7 - 10.5 - 1.2 = 2$ kcal mol$^{-1}$

**26. (d):** Some interhalogens are solids and are not volatile.

**27. (c) :**

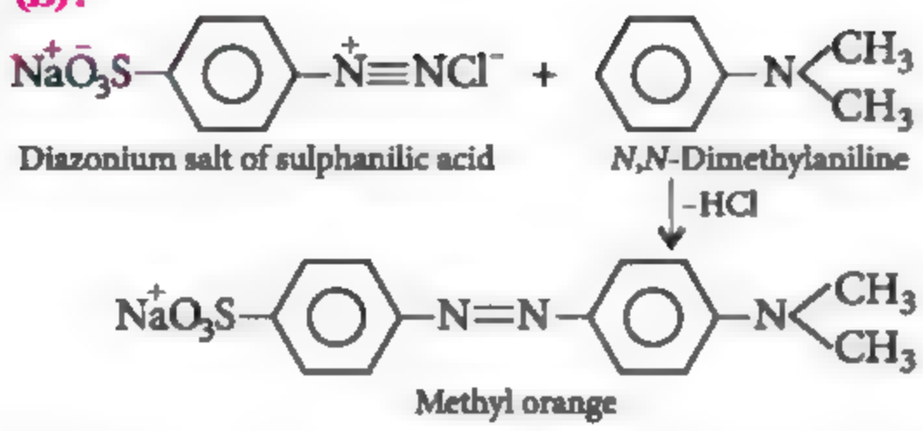



**28. (b):** *Ortho* substituted anilines are weaker bases than anilines regardless of the nature of the substituent whether electron releasing or electron withdrawing. This is called *ortho* effect and is probably due to a combination of steric and electronic factors.




**29. (b):** In Schottky defect, equal number of cations and anions are missing from the lattice.

30. **(b):**




31. **(c) :** $Al(OH)_3$ formed with NaOH dissolves in excess of NaOH to form aluminate ion.

$$AlCl_3 + 3NaOH \longrightarrow Al(OH)_3\downarrow + 3NaCl$$
$$Al(OH)_3 + OH^- \longrightarrow \underset{\text{Soluble}}{[Al(OH)_4]^-}$$

32. **(a) :** For the first four actinide elements, Th, Pa, U and Np, the difference in energy between 5*f* and 6*d*-orbitals is small. Thus, in these elements (and their ions) electrons may occupy the 5*f* or the 6*d* levels or sometimes both. Later in the actinide series the 5*f*-orbitals become appreciably lower in energy. Thus, from Pu onwards the 5*f*-shell fills in a regular way.

33. **(c) :** Raoult's law is valid for ideal solutions only. A solution containing components of *A* and *B* behaves as an ideal solution when *A*—*B* attraction force remains same as *A*—*A* and *B*—*B*.

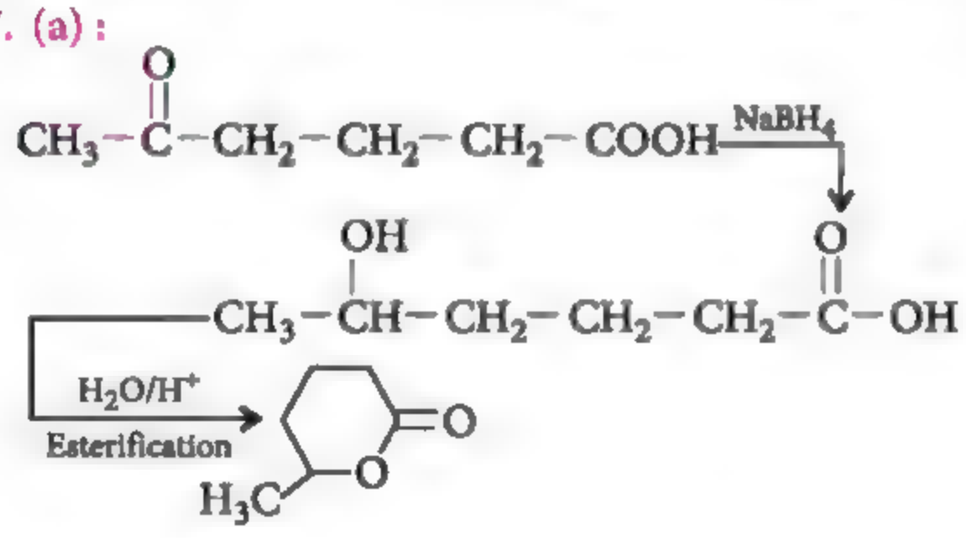
34. **(c) :** Under alkaline conditions of the reagent, fructose gets converted into a mixture of glucose and mannose (Lobry de Bruyn - van Ekenstein rearrangement) both of which contain the –CHO group and hence, reduce Tollens' reagent to give silver mirror test.

35. **(d):** With the increase of temperature, rate of reaction increases and thus rate constant also increases because rate ∝ rate constant.

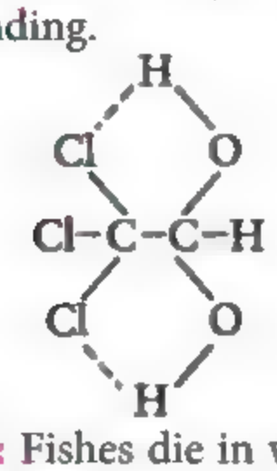
36. **(a) :** When $LiNO_3$ is heated it gives oxide, $NO_2$ and $O_2$ while other nitrates of alkali metals give oxygen and nitrites.

$$4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$$
$$2MNO_3 \rightarrow 2MNO_2 + O_2 \text{ (All Alkali metals except Li)}$$

37. **(a) :**

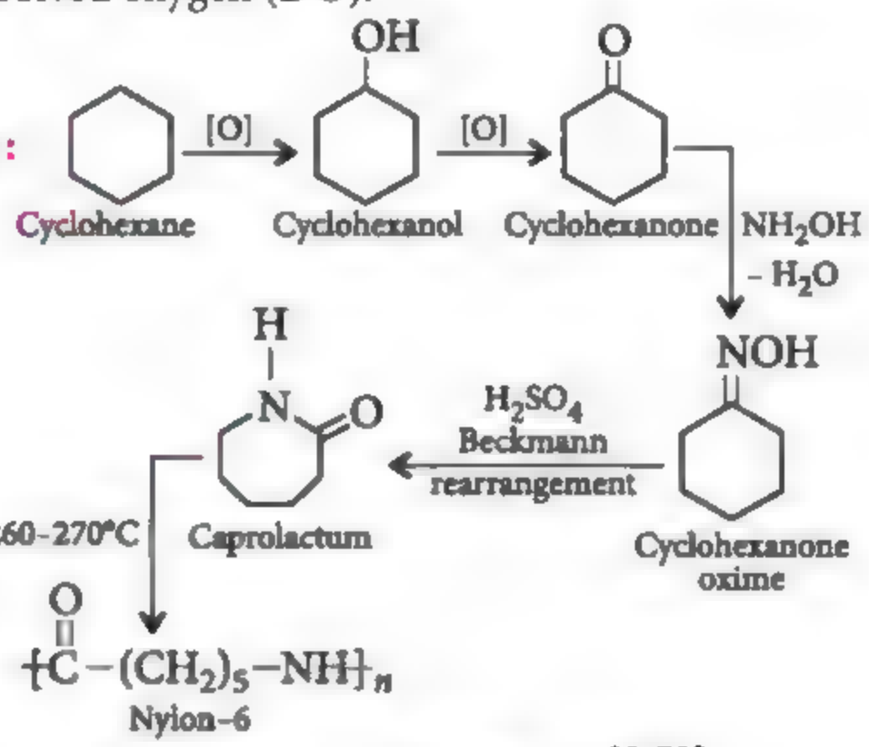



38. **(c) :** Chloral hydrate is stable due to hydrogen bonding.

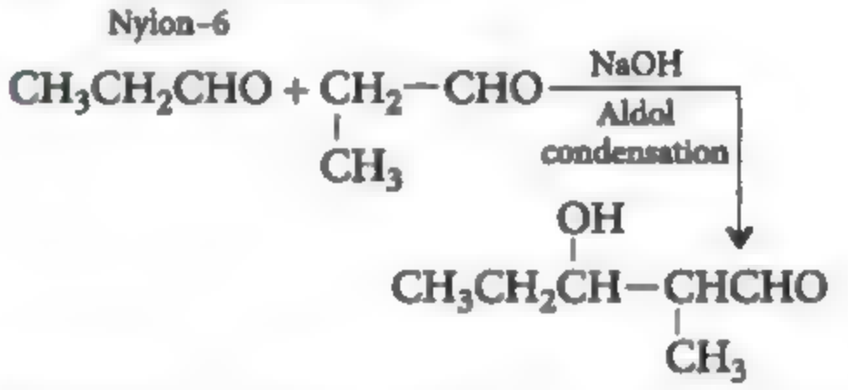


39. **(b):** Fishes die in water bodies having low level of dissolved oxygen (DO).

40. **(c) :**




41. **(c) :**




42. **(a) :** $2KMnO_4 + H_2SO_4 \longrightarrow \underset{\text{(Conc.)}}{K_2SO_4} + \underset{\text{(Explosive)}}{Mn_2O_7} + H_2O$

43. **(c) :** Greater the number of unpaired electrons more will be the magnetic moment.

| **Ion** | $V^{3+}$ | $Cr^{3+}$ | $Fe^{3+}$ | $Co^{3+}$ |
|---|---|---|---|---|
| **Outer electronic configuration** | $3d^2$ | $3d^3$ | $3d^5$ | $3d^6$ |
| **No. of unpaired *d*-electrons** | 2 | 3 | 5 | 4 |

44. **(a) :** Reactions of alcohols involving cleavage of C – OH bond follow the reactivity order :
Tertiary > secondary > primary, according to the stability of carbocation intermediate.

45. **(b):** More basic the leaving group, less reactive is the acyl derivative. Now basicity of the leaving groups decreases in the order :
$CH_3NH^- > C_6H_5NH^- > p\text{-}NO_2 — C_6H_4 — NH^- > Cl^-$,
therefore, $CH_3CONHCH_3$ is the least reactive acyl derivative. ◈◈

# GEAR UP FOR JEE MAIN

EXAM ON 1st - 6th September 2020

**with Numerical Value Type Questions**

1. A white solid (1) on heating evolves $CO_2$ and gives a white residue (2) which is soluble in water. (2) also gives $CO_2$ when treated with dilute acid. (1) and (2) are respectively
   (a) $Na_2CO_3$ and $NaHCO_3$
   (b) $NaHCO_3$ and $Na_2CO_3$
   (c) $CaCO_3$ and $CaHCO_3$
   (d) $CaHCO_3$ and $CaCO_3$

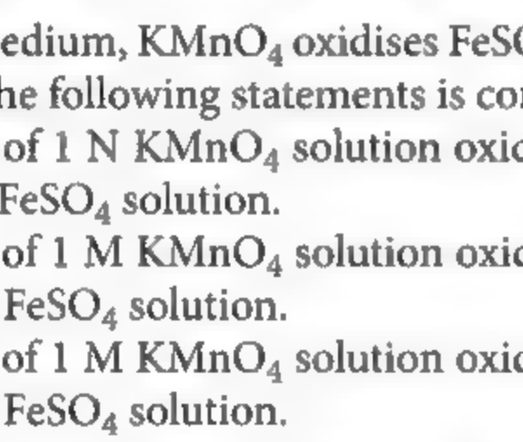
2. Aldol condensation will not be observed in
   (a) chloral (b) phenylacetaldehyde
   (c) hexanal (d) ethanal.

3. In a *fcc* lattice, atom *A* occupies the corner positions and atom *B* occupies the face centred position. If one atom of *B* is missing from one of the face centred points, the formula of the compound is
   (a) $A_2B$ (b) $AB_2$ (c) $A_2B_3$ (d) $A_2B_5$

4. In acidic medium, $KMnO_4$ oxidises $FeSO_4$ solution. Which of the following statements is correct?
   (a) 10 mL of 1 N $KMnO_4$ solution oxidises 10 mL of 5 N $FeSO_4$ solution.
   (b) 10 mL of 1 M $KMnO_4$ solution oxidises 10 mL of 5 M $FeSO_4$ solution.
   (c) 10 mL of 1 M $KMnO_4$ solution oxidises 10 mL of 1 M $FeSO_4$ solution.
   (d) 10 mL of 1 N $KMnO_4$ solution oxidises 10 mL of 0.1 M $FeSO_4$ solution.

5. The polymer in which the intermolecular force of attraction is weakest, is
   (a) nylon (b) polyvinyl chloride
   (c) cellulose (d) natural rubber.

6. Given, $\Delta G^\circ = -nFE^\circ_{cell}$ and $\Delta G^\circ = -RT \ln K$. The value of $n = 2$ will be given by the slope of which line in the figure ?




   (a) *OA* (b) *OB* (c) *OC* (d) *OD*

7. $H_2C_2O_4 \xrightarrow{\Delta}$ gas (*A*) + gas (*B*) + liquid (*C*)
   (Oxalic acid)
   Gas (*A*) burns with a blue flame and is oxidised to gas (*B*). Gas (*B*) turns lime water milky.
   Gas (*A*) + $Cl_2 \longrightarrow$ (*D*) $\xrightarrow{NH_3, \Delta}$ (*E*)
   *A*, *B*, *C*, *D* and *E* are respectively
   (a) $CO_2$, CO, $H_2O$, $HCOONH_2$, $COCl_2$
   (b) CO, $CO_2$, $COCl_2$, $H_2O$, $HCOONH_2$
   (c) CO, $CO_2$, $H_2O$, $COCl_2$, $NH_2CONH_2$
   (d) CO, $CO_2$, $H_2O$, $NH_2CONH_2$, $COCl_2$

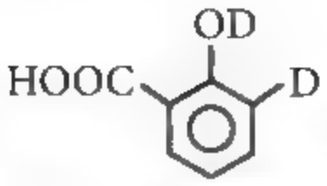
8. Square planar complexes of the type *MABXL* (where *A*, *B*, *X* and *L* are unidentate ligands) shows
   (a) two *cis* and one *trans* isomers
   (b) two *trans* and one *cis* isomers
   (c) two *cis* and two *trans* isomers
   (d) one *cis* and one *trans* isomers.

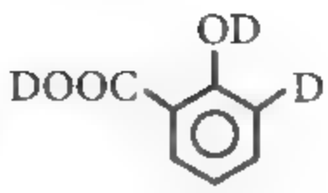
9. One mole of an organic compound consumes 4 moles of periodic acid to form HCHO, HCOOH and CHOCOOH. The organic compound is
   (a) glucose (b) fructose
   (c) gluconic acid (d) sorbitol.

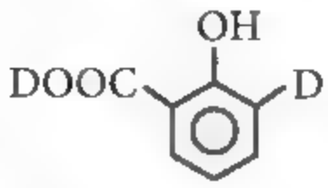
10. At constant temperature, the equilibrium constant ($K_p$) for the decomposition reaction,
    $N_2O_4 \rightleftharpoons 2NO_2$
    is expressed by $K_p = 4x^2P/(1 - x^2)$, where $P$ = pressure and $x$ = extent of decomposition. Which of the following statements is true?
    (a) $K_p$ increases with increase in $P$.
    (b) $K_p$ increases with increase in $x$.
    (c) $K_p$ increases with decrease in $x$.
    (d) $K_p$ remains constant with change in $P$ and $x$.

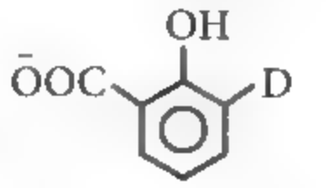
11. 

    Here *P* is

(a) 


(b) 


(c) 


(d) 


**12.** $K_{sp}$ of $Mg(OH)_2$ is $1 \times 10^{-12}$, 0.01 M $MgCl_2$ will be precipitating at the limiting pH
(a) 8 (b) 9 (c) 10 (d) 12

**13.** A white crystalline solid (*A*) on boiling with caustic soda solution gave a gas (*B*) which when passed through an alkaline solution of potassium mercuric iodide gave a brown ppt. The substance (*A*) on heating gave a gas (*C*) which rekindled a glowing splinter but did not give brown fumes with nitric oxide. The gases (*B*), (*C*) and the substance (*A*) respectively are
(a) $H_2S$, $NO_2$, NaCl (b) $NH_3$, $N_2O$, $NH_4NO_3$
(c) HCl, NO, $NH_4Cl$ (d) $CO_2$, $SO_2$, $Na_2SO_3$

**14.** One mole of magnesium in the vapour state absorbed 1200 kJ $mol^{-1}$ of energy. If the first and second ionisation energies of Mg are 750 and 1450 kJ $mol^{-1}$ respectively, the final composition of the mixture is
(a) 31% $Mg^+$ + 69% $Mg^{2+}$
(b) 69% $Mg^+$ + 31% $Mg^{2+}$
(c) 86% $Mg^+$ + 14% $Mg^{2+}$
(d) 14% $Mg^+$ + 86% $Mg^{2+}$

**15.** If the molecular weight of $Na_2S_2O_3$ and $I_2$ are $M_1$ and $M_2$ respectively then what will be the equivalent weights of $Na_2S_2O_3$ and $I_2$ in the following reaction ?

$$2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$$

(a) $M_1$, $M_2$ (b) $M_1$, $M_2/2$
(c) $2M_1$, $M_2$ (d) $M_1$, $2M_2$

**16.** The ionisation energy of hydrogen atom (in the ground state) is *x* kJ. The energy required for an electron to jump from 2nd orbit to the 3rd orbit will be
(a) $x/6$ (b) $5x$ (c) $7.2x$ (d) $5x/36$

**17.** 1 mole of a non ideal gas undergoes a change of state (2.0 atm, 3.0 L, 95 K) ⟶ (4.0 atm, 5.0 L, 245 K) with a change in internal energy, $\Delta U = 30.0$ L atm. The change in enthalpy ($\Delta H$) of the process (in L atm) is
(a) 40.0
(b) 42.3
(c) 44.0
(d) not defined because the pressure is not constant.

**18.** *n*-Butylamine(I), diethylamine(II) and *N*, *N*-dimethylethylamine(III) have the same molar mass. The increasing order of their boiling points is
(a) III < II < I (b) I < II < III
(c) II < III < I (d) II < I < III

**19.** An organic compound (*A*) reacts with methyl magnesium iodide to form an addition product which on hydrolysis forms the compound (*B*). Compound (*B*) gives blue colour salt in Victor Meyer's test. The compound (*A*) and (*B*) are respectively
(a) acetaldehyde, tertiary butyl alcohol
(b) acetaldehyde, ethyl alcohol
(c) acetaldehyde, isopropyl alcohol
(d) acetone, isopropyl alcohol.

**20.** Aluminium chloride exists as dimer, $Al_2Cl_6$ in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives
(a) $[Al(OH)_6]^{3-}$ + HCl (b) $[Al(H_2O)_6]^{3+}$ + $Cl^-$
(c) $Al^{3+}$ + $Cl^-$ (d) $Al_2O_3$ + HCl

## NUMERICAL VALUE TYPE

**21.** The total number of molecules or ions having bond order 2.5 among $O_2^+$, CN, NO, $N_2^+$, $CO^+$, $NO^+$, $O_2^-$, $CN^-$, $N_2$ is/are

**22.** The enthalpy change involved in the oxidation of glucose is −2880 kJ $mol^{-1}$. 25% of this energy is available for muscular work. If 100 kJ of muscular work is needed to walk one kilometre, what is the approximate distance (in km) that a person will be able to walk after eating 120 g of glucose?

**23.** The ratio of terminal to bridged CO groups in $[Co_2(CO)_8]$ is *x* : 1, then the value of *x* is

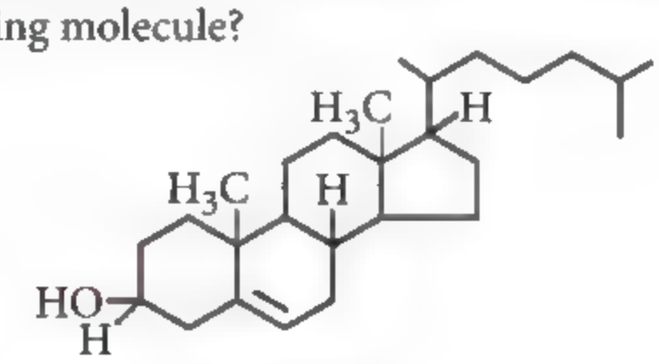
**24.** A vessel contains $A_{(g)}$ and $B_{(g)}$ at 2 atm and 4 atm respectively at *T* K, the mixture is allowed to attain equilibrium at *T* K, according to the reaction,

$$8B_{(g)} \rightleftharpoons 8A_{(g)} + C_{(s)}$$

At equilibrium, $\left(\frac{n_A}{n_B}\right)_{eq.} = \left(\frac{n_B}{n_A}\right)_{initial}$

Find the value of $K_c$.

**25.** How many chiral centres are present in the following molecule?




Cholesterol

## SOLUTIONS

**1. (b):** $2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$

(1) (2) White residue, soluble in water

$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$

(2) (dil.)

**2. (a):** Chloral ($CCl_3CHO$) has no α-hydrogen atom and hence, does not undergo aldol condensation.

**3. (d):** Atom *A* Atom *B*

$Z = 8 \times \frac{1}{8} = 1$ $Z = 5 \times \frac{1}{2} = \frac{5}{2}$

$\Rightarrow A : B = 1 : \frac{5}{2}$ $\Rightarrow 2 : 5$

So, formula of compound will be $A_2B_5$.

**4. (b):** 10 mL of 1 M $KMnO_4$ oxidises 10 mL of 5 M $FeSO_4$ in acidic medium.

$2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$

**5. (d):** Natural rubber has the weakest intermolecular forces among the given *i.e.*, van der Waals' forces of attraction and is an example of an elastomer.

**6. (b):** $-nFE^\circ_{cell} = -RT \ln K$ or $E^\circ_{cell} = \frac{RT}{nF} \ln K$

Plot of $\ln K$ *vs* $E^\circ_{cell}$ will have slope $= \frac{1}{2}\frac{RT}{F}$ $(n = 2)$.

This will only be possible when $E^\circ_{cell} = 0.5$ which is for the line *OB*.

**7. (c):** $H_2C_2O_4 \xrightarrow{\Delta} CO + CO_2 + H_2O$

(*A*) (*B*) (*C*)

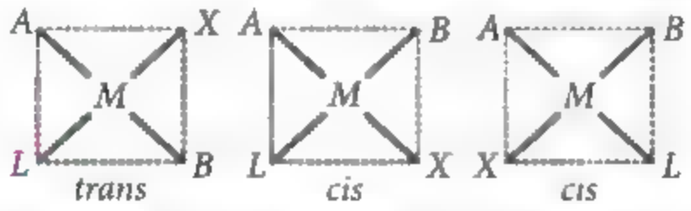
$CO_2 + Ca(OH)_2 \longrightarrow CaCO_3 + H_2O$

(*B*) Lime water Milkiness

$CO + Cl_2 \longrightarrow COCl_2 \xrightarrow[-2\,HCl]{2NH_3/\Delta} NH_2CONH_2$

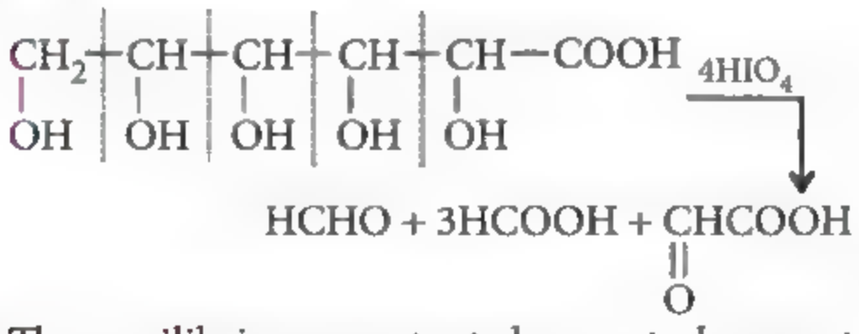
(*A*) (*D*) (*E*)

**8. (a):**



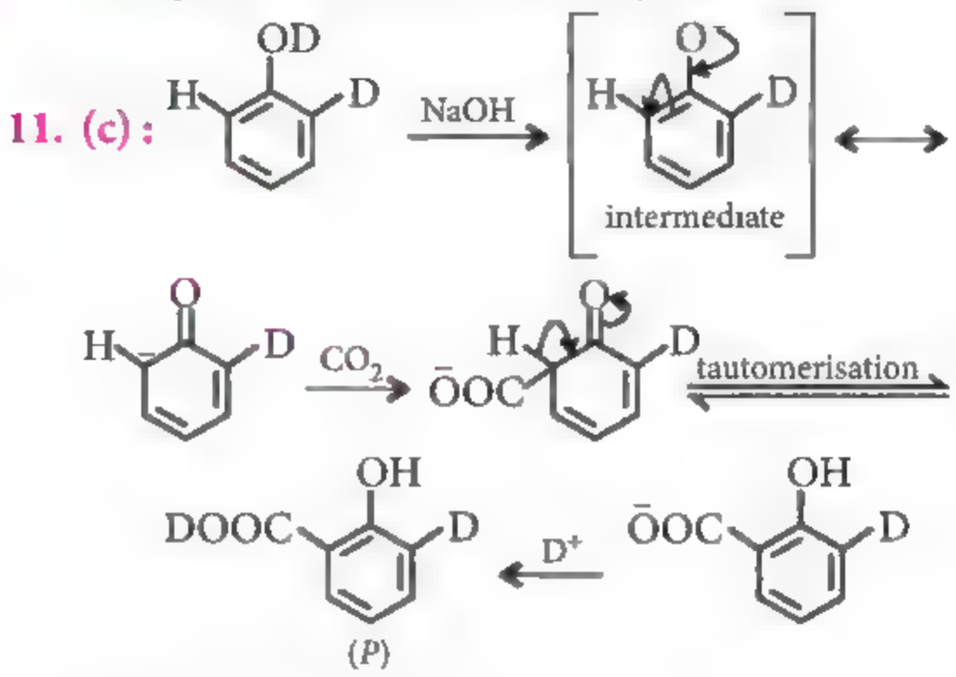

Thus, square planar complex *MABXL* shows two *cis* and one *trans* isomers.

**9. (c):**




**10. (d):** The equilibrium constant does not change at all with change in concentration, volume, pressure and presence of a catalyst. It changes only with change in temperature of the system.

**11. (c):**




**12. (b):** $Mg(OH)_2 \longrightarrow \underset{S}{Mg^{2+}} + \underset{2S}{2OH^-}$

Let $S_1$ is the solubility in 0.01 M $MgCl_2$ (common ion $Mg^{2+}$). $\therefore$ $[Mg^{2+}] = (S_1 + 0.01) \approx 0.01$; $[OH^-] = 2S_1$

$K_{sp} = (0.01)(2S_1)^2$; $S_1 = \left(\frac{K_{sp}}{4 \times 0.01}\right)^{1/2} = \left(\frac{10^{-12}}{4 \times 10^{-2}}\right)^{1/2}$

$= 0.5 \times 10^{-5}$ M

$\therefore$ $[OH^-] = 2S_1 = 2 \times 0.5 \times 10^{-5} = 10^{-5}$ M

pOH = 5, pH = 14 – 5 = 9

**13. (b):** $\underset{(A)}{NH_4NO_3} + NaOH \xrightarrow{\text{boiling}} \underset{(B)}{NaNO_3} + NH_3 + H_2O$

$NH_3$ gives brown ppt. with Nessler's reagent ($K_2HgI_4$).

$2K_2[HgI_4] + NH_3 + 3KOH \longrightarrow \underset{\text{Brown ppt.}}{H_2N \cdot HgO \cdot HgI} + 7KI + 2H_2O$

(*A*) on heating gives $N_2O$ gas (*C*) which rekindles a glowing splinter but is not converted into $NO_2$ by air oxidation.

$\underset{(A)}{NH_4NO_3} \xrightarrow{\Delta} \underset{(C)}{N_2O} + 2H_2O$

**14. (b):** Energy absorbed in the ionisation of 1 mole of $Mg_{(g)}$ to $Mg^+_{(g)}$ = 750 kJ

Energy unconsumed = 1200 – 750 = 450 kJ $mol^{-1}$

This energy is required to convert $Mg^+_{(g)}$ to $Mg^{2+}_{(g)}$.

Thus, % of $Mg^{2+}_{(g)} = \frac{450}{1450} \times \frac{100}{1} = 31\%$ and % of

$Mg^+_{(g)} = 100 - 31 = 69\%$

**15. (b):** $\overset{+2\ -2}{2S_2O_3^{2-}} + \overset{0}{I_2} \longrightarrow \overset{+2.5\ -2}{S_4O_6^{2-}} + 2\overset{-1}{I^-}$

O.N. of S in $S_2O_3^{2-} = 2x - 6 = -2$ or $x = +2$

O.N. of S in $S_4O_6^{2-} = 4x - 12 = -2$ or $x = +2.5$

Change in O.N. of S per mole = 0.5 × 2 = 1

Similarly, change in O.N. of I per mole = 1 × 2 = 2

Therefore, eq. mass of $Na_2S_2O_3 = \frac{M_1}{1} = M_1$, and eq. mass of $I_2 = \frac{M_2}{2}$.

**16. (d):** $(I.E)_H = E_\infty - E_1 = -E_1 = x$

Put $E_1 = -\frac{K}{n^2} = -\frac{K}{1^2} = -K; \quad \therefore \quad K = x$

$$\Delta E = E_3 - E_2 = -\frac{K}{3^2} - \left(-\frac{K}{2^2}\right) = K\frac{5}{36} = \frac{5}{36}x$$

**17. (c):** $H = U + PV$

$H_1 = U_1 + (2 \times 3) = U_1 + 6$

$H_2 = U_2 + (4 \times 5) = U_2 + 20$

$(H_2 - H_1) = (U_2 - U_1) + (20 - 6)$

$\Delta H = \Delta U + 14 = 30 + 14 = 44$ L atm

**18. (a):** $H_3C—CH_2—CH_2—CH_2—NH_2$

*n*-Butylamine (Primary amine)

$CH_3—CH_2—NH—CH_2—CH_3$

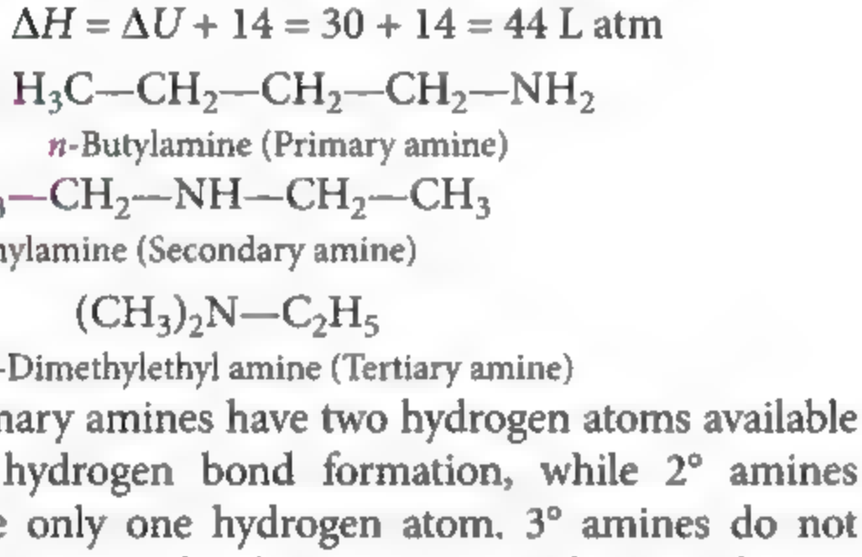
Diethylamine (Secondary amine)

$(CH_3)_2N—C_2H_5$

*N*, *N*-Dimethylethyl amine (Tertiary amine)

Primary amines have two hydrogen atoms available for hydrogen bond formation, while 2° amines have only one hydrogen atom. 3° amines do not have intermolecular association due to absence of hydrogen atom. Thus, order of boiling points of isomeric amines is as follows: 3° < 2° < 1° or III < II < I.

**19. (c):**




2° alcohols give blue coloured salt in Victor Meyer test.

**20. (b):** $Al_2Cl_6 + 12H_2O \rightleftharpoons 2[Al(H_2O)_6]^{3+} + 6Cl^-$

**21. (5):** $O_2^+$, CN, NO, $N_2^+$ and $CO^+$ have bond order of 2.5.

**22. (4.82):** Mass of glucose = 120 g

No. of moles of glucose = $\frac{120}{180} = 0.67$

Heat produced after eating 0.67 mol of glucose

$= 0.67 \times 2880 = 1929.6$ kJ

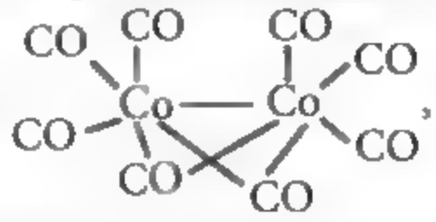
Energy available for muscular work

$= 1929.6 \times \frac{25}{100} = 482.4$ kJ

Approximate distance that a person will walk

$= \frac{482.4}{100} = 4.824$ km

**23. (3):** $[Co_2(CO)_8]$ has six terminal and two bridged CO groups




, the ratio is 6 : 2 *i.e.*, 3 : 1. Hence, the value of $x$ is 3.

**24. (256):**

$$8B_{(g)} \rightleftharpoons 8A_{(g)} + C_{(s)}$$

| | | |
|---|---|---|
| Initial no. of moles : | $\frac{4V}{RT}$ | $\frac{2V}{RT}$ |
| No. of moles at eq. : | $\frac{4V}{RT} - x$ | $\frac{2V}{RT} + x$ |

Given that, at equilibrium,

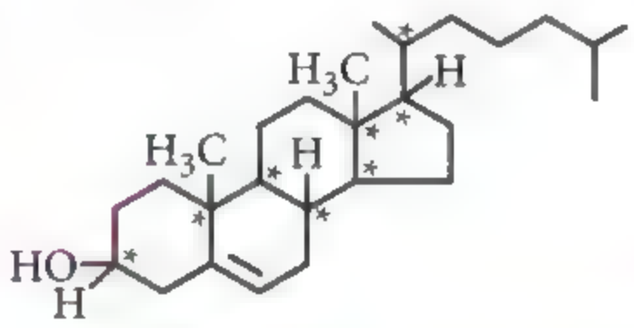
$$\left(\frac{n_A}{n_B}\right)_{eq.} = \left(\frac{n_B}{n_A}\right)_{initial}$$

$$\frac{\frac{2V}{RT} + x}{\frac{4V}{RT} - x} = \frac{\frac{4V}{RT}}{\frac{2V}{RT}}$$

$\therefore \quad x = \frac{2V}{RT}$

$$\therefore \quad K_c = \frac{\left(\frac{4V}{RT}\right)^8}{\left(\frac{2V}{RT}\right)^8} = 2^8 = 256$$

**25. (8):**




Cholesterol

# JEE WORK OUTS

JEE Advanced Exam on 27th September 2020

## SECTION 1

- *This section contains FIVE questions.*
- *Each question has FOUR options (A), (B), (C) and (D). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

**Full Marks :** *+3 If only the bubble corresponding to the correct option is darkened.*

**Zero Marks :** *0 If none of the bubbles is darkened.*

**Negative Marks :** *–1 In all other cases.*

1. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition $n = 4$ to $n = 2$ of $He^+$ spectrum?
   (a) $n_1 = 1$ to $n_2 = 2$ (b) $n_1 = 2$ to $n_2 = 4$
   (c) $n_1 = 1$ to $n_2 = 3$ (d) $n_1 = 2$ to $n_2 = 3$

2. An ideal gas has a specific heat at constant presssure $C_p = \frac{5}{2}R$. The gas is kept in a closed vessel of volume 0.0083 $m^3$, at a temperature of 300 K and pressure $1.6 \times 10^6$ $N/m^2$. An amount of $2.49 \times 10^4$ J of energy is supplied to the gas. The final temperature of the gas is
   (a) 375 K (b) 575 K
   (c) 675 K (d) 475 K

3. In $[Ni(CN)_4]^{2-}$, $[MnBr_4]^{2-}$ and $[CoF_6]^{3-}$ ions, the geometry, hybridisation and magnetic moment, respectively are
   (a) tetrahedral, square planar, octahedral ;
   $sp^3$, $dsp^2$, $sp^3d^2$ ; 5.9, 0, 4.9
   (b) tetrahedral, square planar, octahedral ;
   $dsp^2$, $sp^3$, $sp^3d^2$ ; 0, 5.9, 4.9
   (c) square planar, tetrahedral, octahedral ;
   $dsp^2$, $sp^3$, $d^2sp^3$ ; 5.9, 4.9, 0
   (d) square planar, tetrahedral, octahedral ;
   $dsp^2$, $sp^3$, $sp^3d^2$ ; 0, 5.9, 4.9

4. In which of the following arrangements, the order is not according to the property indicated against it?
   (a) $Al^{3+} < Mg^{2+} < Na^+ < F^-$ (increasing ionic size)
   (b) B < C < N < O
   (increasing first ionisation enthalpy)
   (c) I < Br < F < Cl (increasing electron gain enthalpy with negative sign)
   (d) Li < Na < K < Rb (increasing metallic radius)

5. In a polymer sample, 30% of molecules have a molecular mass of 20,000, 40% have 30,000 and the rest 60,000. What is the weight average molecular mass of the polymer?
   (a) 40,300 (b) 30,600
   (c) 43,333 (d) 33,353

## SECTION 2

- *This section contains EIGHT questions.*
- *Each question has FOUR options (A), (B), (C) and (D). ONE OR MORE THAN ONE of these four option(s) is(are) correct.*
- *For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

**Full Marks :** *+4 If only the bubble(s) corresponding to the correct option(s) is(are) darkened.*

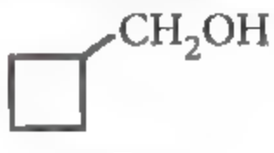
**Partial Marks :** *+1 For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.*

**Zero Marks :** *0 If none of the bubbles is darkened.*

**Negative Marks :** *–2 In all other cases.*

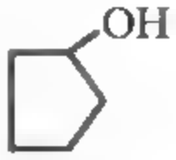
- *For example, if (A), (C) and (D) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (A) and (D) will result in +2 marks; and darkening (A) and (B) will result in –2 marks, as a wrong option is also darkened.*

**6.** Treatment of cyclobutylmethylamine with nitrous acid does not give

(a) 

(b) 

(c) 

(d) 

**7.** The reagent(s) required for the conversion;
$RCH{=}CHR' \longrightarrow RCOOH + HOOCR'$ is/are
(a) $O_3$ followed by treatment with $H_2O_2$
(b) hot $KMnO_4$/KOH followed by acidification
(c) Lemieux reagent (d) Baeyer's reagent.

**8.** The pairs of compounds which cannot exist together in aqueous solution are
(a) $NaH_2PO_4$ and $Na_2HPO_4$
(b) NaOH and $NaH_2PO_4$
(c) $Na_2CO_3$ and $NaHCO_3$
(d) $NaHCO_3$ and NaOH

**9.** Which of the following options is/are correct regarding $XeF_6$?
(a) It acts as a Lewis acid when it reacts with RbF.
(b) It undergoes complete hydrolysis to give $XeO_3$.
(c) It fluorinates silica ($SiO_2$) to give $XeOF_4$.
(d) Hybridisation of $XeF_6$ is $sp^3d^2$ with octahedral geometry.

**10.** Two radioisotopes *P* and *Q* with atomic masses 100 u and 200 u respectively are mixed in equal amount by mass. After 20 days, their mass ratio is found to be 1 : 4. If $t_{1/2}$ for *P* is 10 days, then $t_{1/2}$ for *Q* is
(a) ∞ days (b) 10 days
(c) 5 days (d) 20 days.

## SECTION 3

- *This section contains SIX (06) questions. The answer to each question is a NUMERICAL VALUE.*
- *For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/ round-off the value to TWO decimal places.*
- *Answer to each question will be evaluated according to the following marking scheme:*
  **Full Marks :** *+3 If ONLY the correct numerical value is entered.*
  **Zero Marks ::** *0 In all other cases.*

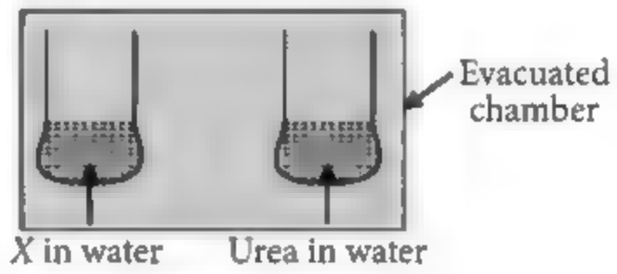
**11.** Tropic acid (obtained from the alkaloid atropine), $C_9H_{10}O_3$, gives a positive $CrO_3/H_2SO_4$ test at 273 K and is oxidised by hot $KMnO_4$ to benzoic acid. Tropic acid is converted by the following sequence of reactions into hydratropic acid :

$$\text{Tropic acid} \xrightarrow{HBr} (C_9H_9O_2Br) \xrightarrow{OH^-} (C_9H_8O_2)\text{(Atropic acid)}$$

$$\text{Atropic acid} \xrightarrow{H_2,Ni} \text{Hydratropic acid}(C_9H_{10}O_2)$$

Number of carbon atoms in the ring in tropic acid is

**12.** Two aqueous solutions as shown, are put in an evacuated chamber. When equilibrium is attained, it is found that one solution contains 0.01% of *X* and other 0.02% of urea by weight. The molecular weight of *X* is (*X* is non-electrolyte and non-volatile solute)




**13.** Total number of geometrical isomers for the complex $[RhCl(CO)(PPh_3)(NH_3)]$ is

**14.** How many electrons are transferred when $KMnO_4$ acts as oxidising agent to give $Mn(OH)_3$?

**15.** The compressibility factor for 1 mole of a van der Waals gas at 0°C and 100 atm pressure is found to be 0.5. Assuming that the volume of a gas molecule is negligible, the van der Waals constant, *a* is

**16.** CsCl has cubic structure. Its density is 3.99 g $cm^{-3}$. The distance between $Cs^+$ and $Cl^-$ ions in pm is (Atomic mass of Cs = 133)

## SECTION 4

- *This section contains TWO paragraphs.*
- *Based on each paragraph, there are TWO questions.*
- *Each question has FOUR options (A), (B), (C) and (D). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

**Full Marks :** *+3 If only the bubble corresponding to the correct option is darkened.*

**Zero Marks :** *0 In all other cases.*

## PARAGRAPH 1

Decomposition of ammonium chloride is an endothermic reaction. The equilibrium may be represented as :

$$NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$$

A 6.250 g sample of $NH_4Cl$ is placed in an evacuated 4.0 L container at 27°C. After equilibrium the total pressure inside the container is 0.820 bar and some solid remains in the container.

**17.** The value of $K_p$ for the reaction at 300 K is

(a) 16.2 (b) 0.168

(c) 1.68 (d) 32.4

**18.** The amount of solid $NH_4Cl$ left behind in the container at equilibrium is

(a) 2.996 (b) 28.56

(c) 0.2856 (d) 1.320

## PARAGRAPH 2

A mixture of two compounds *A* and *B* was separated by dissolving in chloroform followed by extraction with aqueous KOH solution. The organic layer containing compound *A*, when heated with alcoholic solution of KOH produced a compound $C(C_7H_5N)$ associated with an unpleasant odour. The alkaline aqueous layer on the other hand, when heated with chloroform and then acidified gave a mixture of two isomeric compounds *D* and *E* of molecular formula $C_7H_6O_2$.

**19.** Compounds *A* and *B* respectively are

(a) $C_6H_5OH$, $C_6H_5OCH_3$

(b) $C_6H_5NH_2$, $C_6H_5OH$

(c) $C_6H_5OH$, $C_6H_5NH_2$

(d) $C_6H_5CH_2OH$, $C_6H_5CH_2NH_2$

**20.** The compounds *D* and *E* respectively are

(a) $C_6H_5CHO$, *o*-HO—$C_6H_4CHO$

(b) $C_6H_5CHO$, *m*-HO—$C_6H_4CHO$

(c) $C_6H_5CHO$, *p*-HO—$C_6H_4CHO$

(d) *o*-HO—$C_6H_4CHO$, *p*-HO—$C_6H_4CHO$

## SOLUTIONS

**1. (a) :** $\bar{\nu}_H = \frac{1}{\lambda_H} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ ...(i)

$$\bar{\nu}_{He^+} = \frac{1}{\lambda_{He^+}} = RZ^2\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

$$= R \times 4\left(\frac{1}{4} - \frac{1}{16}\right) = R \times \left(\frac{4}{4} - \frac{4}{16}\right)$$

$$= R \times \left(1 - \frac{1}{4}\right) \quad \text{...(ii)}$$

Comparing equations (i) and (ii), we get

$\therefore \quad \Rightarrow n_1 = 1$ and $n_2 = 2$

**2. (c) :** Suppose *n* moles of gas are present.

$$\therefore \quad n = \frac{PV}{RT} = \frac{1.6\times10^6 \times 0.0083}{8.3\times300} = 5.33$$

$$C_v = \frac{5}{2}R - R = \frac{3}{2}R = \frac{3}{2} \times 8.3 = 12.45 \text{ J mol}^{-1} \text{ K}^{-1}$$

Heat supplied at constant volume $(q_v) = n \times C_v \times \Delta T$

$$2.49 \times 10^4 = 5.33 \times 12.45 \times \Delta T$$

$$\Delta T = \frac{2.49\times10^4}{5.33\times12.45} \Rightarrow \Delta T \approx 375 \text{ K}$$

$\therefore$ Final temperature, $T_f = 300 + 375 = 675$ K

**3. (d):** In $[Ni(CN)_4]^{2-}$, $Ni^{2+} = 3d^8$, $dsp^2$ hybridisation (square planar geometry), no unpaired electron is present and magnetic moment is zero.

In $[MnBr_4]^{2-}$, $Mn^{2+} = 3d^5$, $sp^3$ hybridisation (tetrahedral geometry), $n = 5$,

$\mu = \sqrt{5(5+2)}$ B.M. $= \sqrt{35}$ B.M. $= 5.9$ B.M.

In $[CoF_6]^{3-}$, $Co^{3+} = 3d^6$, $sp^3d^2$ hybridisation (octahedral geometry),

$n = 4$, $\mu = \sqrt{4(4+2)}$ B.M. $= \sqrt{24}$ B.M. $= 4.9$ B.M.

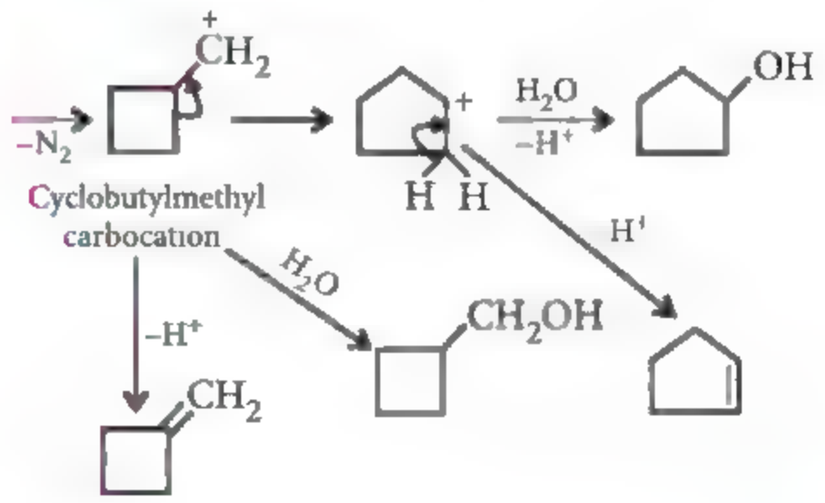
**4. (b)**

**5. (c) :** $\bar{M}_w = \frac{\sum N_i M_i^2}{\sum N_i M_i}$

$$\bar{M}_w = \frac{30(20000)^2 + 40(30000)^2 + 30(60000)^2}{(30\times20000) + (40\times30000) + (30\times60000)}$$

$$= 43{,}333.33 \approx 43{,}333$$

**6. (b):**

**7. (a, b) :** $RCH=CHR' \xrightarrow[(ii)\ NaIO_4]{(i)\ KMnO_4} RCHO + R'CHO$

A solution of $NaIO_4$ containing a trace of $KMnO_4$ is called Lemieux reagent.

**8. (b, d) :** $2NaOH + NaH_2PO_4 \longrightarrow Na_3PO_4 + 2H_2O$

$NaHCO_3 + NaOH \longrightarrow Na_2CO_3 + H_2O$

**9. (a, b, c) :**

$RbF + XeF_6 \longrightarrow Rb^+[XeF_7]^-$

$XeF_6 + 3H_2O \longrightarrow XeO_3 + 6HF$

$2XeF_6 + SiO_2 \longrightarrow 2XeOF_4 + SiF_4$

$XeF_6$ is $sp^3d^3$ hybridised with pentagonal bipyramidal geometry.

**10. (a) :** Let $w$ g of each be taken.

Initial mole of $P = \frac{w}{100}$ ; Final mole of $P = \frac{w}{5\times100}$

Initial mole of $Q = \frac{w}{200}$ ; Final mole of $Q = \frac{4w}{5\times200}$

For $P$: $\left(\frac{N_0}{N}\right)_P = e^{\lambda_1 t}$ or $\frac{w\times5\times100}{100\times w} = e^{\lambda_1\times20}$ ...(i)

For $Q$: $\left(\frac{N_0}{N}\right)_Q = e^{\lambda_2 t}$ or $\frac{w\times5\times200}{200\times w\times4} = e^{\lambda_2\times20}$ ...(ii)

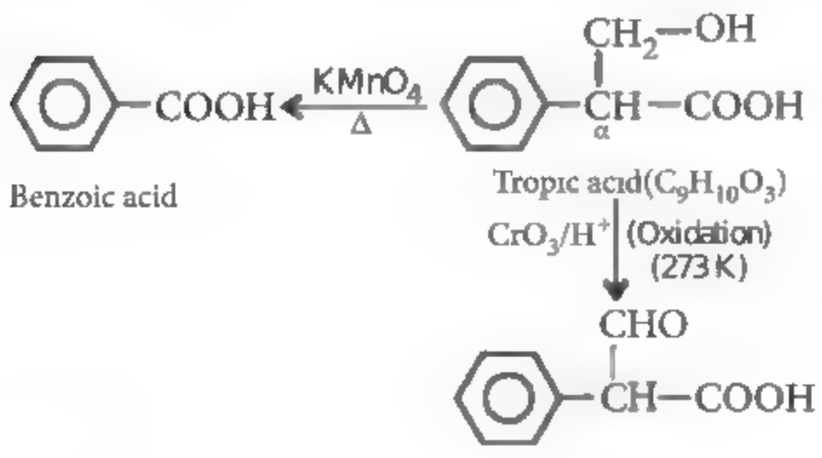
By eqs. (i) and (ii), $4 = e^{(\lambda_1-\lambda_2)\times20}$

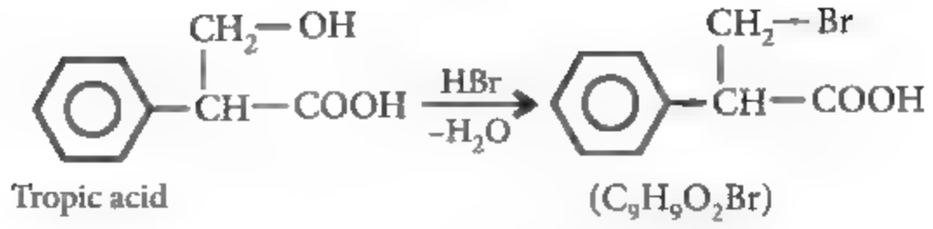
or $\lambda_1 - \lambda_2 = \frac{\log_e 4}{20}$

or $\frac{0.693}{10} - \frac{0.693}{t} = \frac{\log_e 4}{20} \Rightarrow t = \infty$

**11. (6) :** (a) Since tropic acid is oxidised by $CrO_3/H_2SO_4$, it suggests the presence of $>$CH—OH or —$CH_2$—OH group in it.

(b) Tropic acid is also oxidised by hot alkaline $KMnO_4$ into benzoic acid, indicating the presence of a benzene nucleus and atleast one α H-atom in the side chain of tropic acid. Thus, tropic acid should have the following structure :

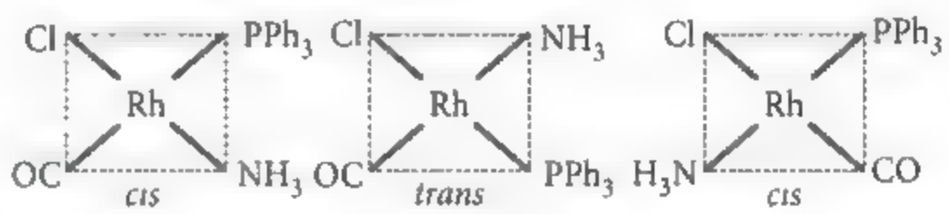



**12. (30) :** At equilibrium, lowering in vapour pressure of both the solutions is same.

Then, $\frac{0.01}{M_X} = \frac{0.02}{60} \Rightarrow M_X = 30$ amu

**13. (3) :** $[RhCl(CO)(PPh_3)(NH_3)]$ is a square planar complex of the type *MABCD*. Hence, it has three geometrical isomers as follows :




**14. (4)**

**15. (1.25) :** $Z = \frac{PV}{RT}$ ; $0.5 = \frac{100\times V}{0.0821\times273}$ ; $V = 0.112$ L

Neglecting $b$, van der Waals equation reduces to

$\left(P + \frac{a}{V^2}\right)V = RT$ or $PV + \frac{a}{V} = RT$

or $100\times0.112 + \frac{a}{0.112} = 0.0821\times273$

$a = 1.25\ L^2$ atm $mol^{-2}$

**16. (356.8) :** CsCl has *bcc* structure, so $Z_{eff} = 1$

$\rho = \frac{Z_{eff}\times M}{a^3\times10^{-30}\times N_A}$ or $a^3 = \frac{Z_{eff}\times M}{\rho\times10^{-30}\times N_A}$

$= \frac{1\times(133+35.5)}{3.99\times10^{-30}\times6.02\times10^{23}} = 70.15\times10^6$

$a = (70.15)^{1/3}\times10^2 = 4.12\times10^2$ pm $= 412$ pm

$\text{Interionic distance} = \frac{\sqrt{3}a}{2} = \frac{1.732}{2}\times412 = 356.8$ pm

**17. (b) :** $P_{NH_3} = P_{HCl} = \frac{0.820}{2}$ bar

$\therefore \quad K_p = P_{NH_3}\times P_{HCl} = 0.41\times0.41 = 0.168$

**18. (a) :** Moles of gases, $n = \frac{PV}{RT} = \frac{0.820 \times 4}{0.083 \times 300}$

$= 0.132$ mol

Moles of $NH_3$ = Moles of HCl = $\frac{0.132}{2} = 0.066$

Moles of $NH_4Cl$ decomposed = Moles of $NH_3 = 0.066$

Moles of $NH_4Cl$ initially present = $\frac{6.250}{53.5} = 0.117$

Moles of $NH_4Cl$ left = 0.117 – 0.066 = 0.051

Mass of $NH_4Cl$ left behind = $0.051 \times 53.5 = 2.73$ g

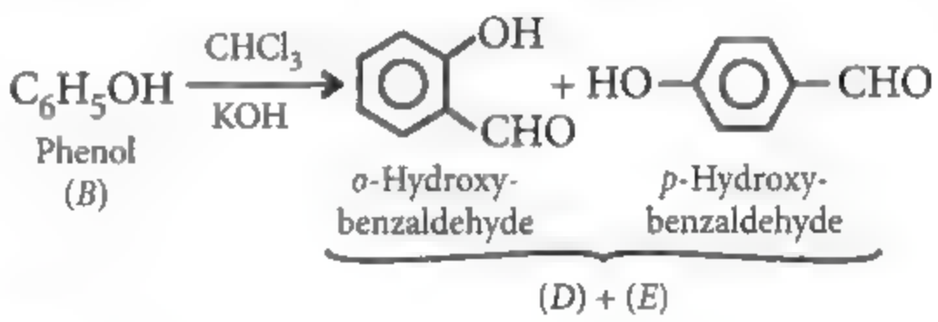
**19. (b)**

Mixture of $(A) + (B) \xrightarrow[+ \text{ aq. KOH}]{CHCl_3}$ Organic layer $(A)$ + Aqueous alkaline layer $(B)$.

Since compound $(A)$ does not dissolve in alkali, therefore, it may be an amine. Further, since on treatment with $CHCl_3$ and alcoholic KOH, it produces $C(C_7H_5N)$ having unpleasant smell, therefore, $(A)$ may be $C_6H_5NH_2$ and $(C)$ must be $C_6H_5NC$ and the name of the reaction is carbylamine reaction.

$$\underset{\text{Aniline}(A)}{C_6H_5NH_2} + CHCl_3 + 3KOH \xrightarrow[(\text{Carbylamine reaction})]{\text{Warm}} \underset{\text{Phenyl isocyanide } (C)\text{ (unpleasant smell)}}{C_6H_5NC} + 3KCl + 3H_2O$$

Since aqueous alkaline layer $(B)$ on heating with $CHCl_3$ followed by acidification gives two isomeric compounds having molecular formula $(C_7H_6O_2)$. Therefore, $(B)$ must be phenol, $C_6H_5OH$. It undergoes Reimer–Tiemann reaction to give a mixture of two isomeric compounds with molecular formula $C_7H_6O_2$. Thus, $(D)$and $(E)$ are *o*- and *p*-hydroxybenzaldehyde.




**20. (d)**

BRUSH UP for NEET/JEE

CLASS-XII

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2021

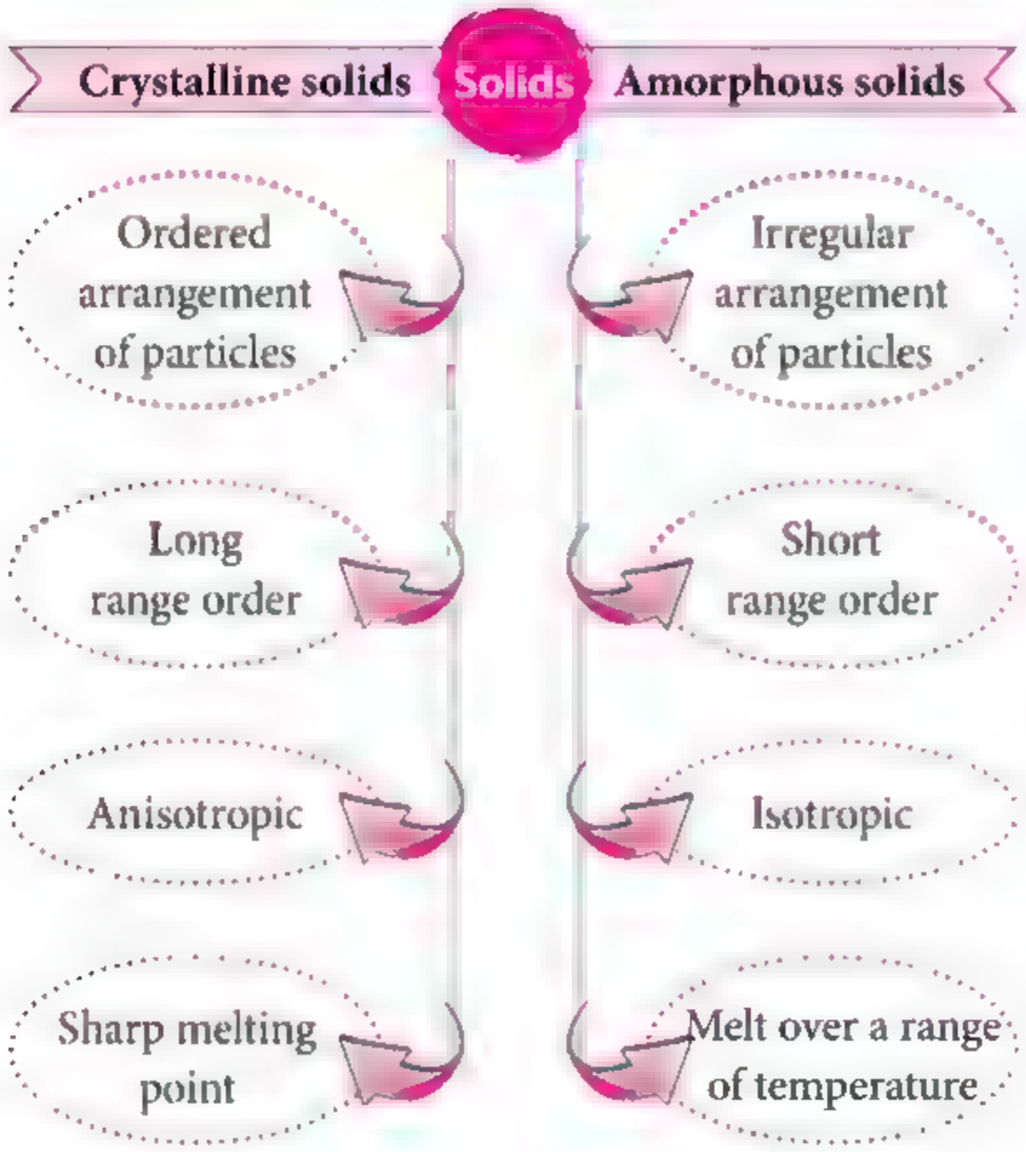
Unit 1

# The Solid State | Solutions

## The Solid State

The *solid state* represents the physical state of matter in which constituents have no translatory motion although vibratory or rotational motions are possible about their position in solid lattice.

### Classification of Solids




### Types of Crystalline Solids

| | |
|---|---|
| **Ionic solids** | **Constituent particles :** Ions of opposite charge<br>**Binding forces :** Electrostatic forces |
| **Covalent solids** | **Constituent particles :** Atoms<br>**Binding forces :** Covalent bonds |
| **Molecular solids** | **Constituent particles :** Molecules<br>**Binding forces :** van der Waals forces |
| **Metallic solids** | **Constituent particles :** Kernels and electrons<br>**Binding forces :** Metallic bonds |

### Bragg's Law

When a beam of *X*-rays of wavelength $\lambda$, strikes a crystal surface, the maximum intensity of reflected rays occur when

$$\sin\theta = \frac{n\lambda}{2d} \quad \text{or} \quad n\lambda = 2d\sin\theta \qquad \text{(Bragg's equation)}$$

It helps in the determination of crystal structure.

## Crystal Systems and Bravais Lattices

On the basis of primitives or axial distances and interfacial angles of a unit cell, there are seven crystal systems and fourteen Bravais lattices.

| Crystal systems | Unit cell dimensions and angles | Bravais lattices | Examples |
|---|---|---|---|
| Cubic (most symmetrical) | $a = b = c$; $\alpha = \beta = \gamma = 90°$ | Primitive, Body centred, Face centred | Cu, Zinc blende, KCl, NaCl |
| Orthorhombic | $a \neq b \neq c$; $\alpha = \beta = \gamma = 90°$ | Primitive, Body centred, End centred, Face centred | Rhombic sulphur, $KNO_3$, $BaSO_4$ |
| Tetragonal | $a = b \neq c$; $\alpha = \beta = \gamma = 90°$ | Primitive, Body centred | Sn(White tin), $SnO_2$, $TiO_2$, $CaSO_4$ |
| Monoclinic | $a \neq b \neq c$; $\alpha = \gamma = 90° \neq \beta$ | Primitive, End centred | Monoclinic sulphur, $PbCrO_4$, $Na_2SO_4 . 10H_2O$ |
| Rhombohedral | $a = b = c$; $\alpha = \beta = \gamma \neq 90°$ | Primitive | $CaCO_3$ (Calcite), HgS (Cinnabar) |
| Triclinic (most unsymmetrical) | $a \neq b \neq c$; $\alpha \neq \beta \neq \gamma \neq 90°$ | Primitive | $K_2Cr_2O_7$, $CuSO_4 \cdot 5H_2O$, $H_3BO_3$ |
| Hexagonal | $a = b \neq c$; $\alpha = \beta = 90°$; $\gamma = 120°$ | Primitive | Graphite, ZnO, CdS |

## Packing in Solids

- No. of particles ($Z$) = 1
- *AAA* ... type arrangement
- Packing efficiency = 52.4%
- C.No. = 6

**Simple cubic packing**

**Body centred cubic packing**

- No. of particles ($Z$) = 2
- Slightly open square close packing in first layer. In second layer, spheres are on the top of hollows. Third layer is exactly over the first layer and so on.
- Packing efficiency = 68%
- C.No. = 8

- No. of particles ($Z$) = 4
- *ABCABC* ... type arrangement
- Packing efficiency = 74%
- C.No. = 12

**Face centred cubic packing**

**Hexagonal close packing**

- No. of particles ($Z$) = 6
- *ABAB* ... type arrangement
- Packing efficiency = 74%
- C.No. = 12

## Voids

If $N$ is the number of close packed spheres, then

- number of octahedral voids generated = $N$
- number of tetrahedral voids generated = $2N$

In *ccp* or *fcc*, total no. of voids per unit cell = 12

In *hcp*, total no. of voids per unit cell = 18

## Calculations Involving Unit Cell Parameters

$$\text{Density of unit cell } (\rho) = \frac{Z \times M}{N_0 \times a^3}$$

## Limiting Radius Ratio, Coordination Number and Geometry

| $r_+/r_-$ | C. No. | Geometry |
|---|---|---|
| < 0.155 | 2 | Linear |
| 0.155 - 0.225 | 3 | Trigonal planar |
| 0.225 - 0.414 | 4 | Tetrahedral |
| 0.414 - 0.732 | 6 | Octahedral |
| 0.732 - 1.000 | 8 | Cubic (body centred) |

## Imperfections in Solids

**Imperfections/ Defects in Solids**

**Point defects**
Deviations from ideal arrangement around a point or an atom.

**Line defects**
Deviations from ideal arrangement in entire rows of lattice points.

**Stoichiometric/Intrinsic/Thermodynamic defects**
Do not disturb stoichiometry of solids.

- **Vacancy defect :** Arises when lattice sites are vacant. Decreases density, shown by non-ionic solids.
- **Interstitial defect :** Arises when constituent particles occupy interstitial site. Increases density, shown by non-ionic solids.
- **Frenkel defect :** Smaller ion (usually cation) dislocates from its normal site to an interstitial site. Does not change density, shown by ionic solids, *e.g.*, ZnS, AgCl, AgBr, AgI, etc.
- **Schottky defect :** Arises when equal number of cations and anions are missing. Decreases density, shown by ionic solids, *e.g.*, NaCl, KCl, CsCl, AgBr, etc.

**Impurity defects**
Arise when foreign atoms are present at lattice sites *e.g.*, $SrCl_2$ in NaCl, $CdCl_2$ in AgCl, etc.

**Non-stoichiometric defects**
Disturb stoichiometry of solids.

**Metal excess defect**

**Due to anionic vacancies**
A negative ion is missing from its lattice site, leaving a 'hole' which is occupied by an electron to maintain electrical neutrality, *e.g.*, LiCl, NaCl.

**Due to presence of extra cations**
Usually arises when metal oxides are heated, *e.g.*, ZnO.

**Metal deficiency defect**
Arises when metal shows variable valency *e.g.*, $Fe^{2+}$, $Fe^{3+}$.

## Electrical Properties

**Electrical Properties**

**Conductors**
Conductivity range : $10^4$ to $10^7$ ohm$^{-1}$ m$^{-1}$

**Insulators**
Conductivity range : $10^{-20}$ to $10^{-10}$ ohm$^{-1}$ m$^{-1}$

**Semiconductors**
Conductivity range : $10^{-6}$ to $10^4$ ohm$^{-1}$ m$^{-1}$

- ***n*-type semiconductors :** Group 14 element like Si or Ge doped with group 15 element like P or As etc., free electrons increase conductivity.
- ***p*-type semiconductors :** Group 14 element like Si or Ge doped with group 13 element like B, Al or Ga, holes increase conductivity.

## Magnetic Properties

**Magnetic Properties**

| Paramagnetic | Diamagnetic | Ferromagnetic | Ferrimagnetic | Antiferromagnetic |
|---|---|---|---|---|
| Contains atleast one unpaired electron in the orbital thus, weakly attracted by the magnetic field *e.g.*, $O_2$, $Cu^{2+}$. | All electrons are paired and orbitals are completely filled thus, weakly repelled by the magnetic field. *e.g.*, NaCl, $H_2O$. | Unpaired electrons in same direction thus, strongly attracted by the magnetic fields and can be permanently magnetised. *e.g.*, Ni. | Unequal no. of parallel and anti-parallel arrangement of magnetic moments thus, have small net magnetic moment *e.g.*, $Fe_3O_4$. | Equal number of domains in opposite direction thus, no net magnetic moment. *e.g.*, MnO. |

## Dielectric Properties


**Piezoelectricity :** The electricity produced when mechanical stress is applied on polar crystals *e.g.*, $PbZrO_3$, $NH_4H_2PO_4$ and quartz.

**Ferroelectricity :** In some piezoelectric crystals, the dipoles are permanently polarized even in the absence of electric field. However, on applying electric field, the direction of polarization changes. *e.g.*, $BaTiO_3$, $KH_2PO_4$, Rochelle salt.

**Pyroelectricity :** The electricity produced when some polar crystals are heated. *e.g.*, Crystals of tartaric acid.

**Anti-ferroelectricity :** In some piezoelectric crystals, the dipoles in alternate polyhedra point up and down so, that the crystal does not possess any net dipole moment. *e.g.*, $PbZrO_3$.


**Hardest amorphous substance that disappears on reducing pressure!**

At high temperature of above 700 K and under extremely high pressure ($10^5$ - $10^6$ atm) $CO_2$ forms a 'silica like solid' named, Carbonia (Greenhouse glass). Though it is hardest amorphous solid but interesting thing is that it disappears when pressure is reduced because $CO_2$ is not stable in solid state, under ordinary pressure.

# Solutions

## Solution and its Types

- *Solution* is a perfectly homogeneous mixture (having number of phases equal to one) of two or more components.
- **Different Types of Binary Solutions**

| S.No. | Solute | Solvent | Example |
|---|---|---|---|
| 1. | Solid | Solid | Alloy |
| 2. | Solid | Liquid | Sugar solution in water |
| 3. | Solid | Gas | Iodine vapours in air |
| 4. | Liquid | Solid | Hydrated salt |
| 5. | Liquid | Liquid | Ethanol in water |
| 6. | Liquid | Gas | Water vapours in air |
| 7. | Gas | Solid | Dissolved gases in minerals |
| 8. | Gas | Liquid | Aerated drinks |
| 9. | Gas | Gas | Air |

- *Solubility* of a substance is its maximum amount that can be dissolved in a specified amount of solvent at a specified temperature.
- **Factors affecting solubility of a solid in a liquid :**
  - **Nature of solute and solvent :** Polar solutes dissolve in polar solvents and non-polar solutes in non-polar solvents. (*i.e.*, like dissolves like).
  - **Effect of temperature :**
    - If the dissolution process is endothermic ($\Delta_{sol}H > 0$), the solubility increases with rise in temperature.
    - If dissolution process is exothermic ($\Delta_{sol}H < 0$) the solubility decreases with rise in temperature.
  - **Effect of pressure** : Pressure does not have any significant effect on solubility of solids in liquids as these are highly incompressible.
- **Factors affecting solubility of a gas in a liquid :**
  - **Effect of pressure :** Henry's law states that "the partial pressure of the gas in vapour phase ($p$) is proportional to the mole fraction of the gas ($x$) in the solution" $p = K_H x$.
    Higher the value of $K_H$ at a given pressure, the lower is the solubility of the gas in the liquid.
  - **Effect of temperature :** As dissolution is an exothermic process, then according to Le Chatelier's Principle, the solubility should decrease with increase of temperature.

## Methods for Expressing Concentration of Solutions

Mass percentage, $\left(\frac{w}{W}\right)\% = \frac{w_2}{(w_1 + w_2)} \times 100$

Volume percentage, $\left(\frac{v}{V}\right)\% = \frac{V_2}{(V_1 + V_2)} \times 100$

Mass by volume percentage, $\left(\frac{w}{V}\right)\% = \frac{w_2}{V_{\text{solution}}\,(\text{in mL})} \times 100$

Strength $(\text{g L}^{-1}) = \frac{w_2\,(\text{in g})}{V_{\text{solution}}\,(\text{in mL})} \times 1000$

Mass fraction, $\left(\frac{w}{W_{\text{total}}}\right) \Rightarrow x_1 = \frac{w_1}{w_1 + w_2}$ or $x_2 = \frac{w_2}{w_1 + w_2}$

Parts per million (ppm) $= \frac{w_2}{(w_1 + w_2)} \times 10^6$

Molarity, $(M)$ $(\text{mol L}^{-1}) = \frac{w_2 \times 1000}{M_2 \times V_{\text{solution}}\,(\text{in mL})}$

Molality, $(m)$ $(\text{mol kg}^{-1}) = \frac{w_2 \times 1000}{M_2 \times w_1\,(\text{in g})}$

Normality, $(N)$ $(\text{g-eq L}^{-1}) = \frac{w_2 \times 1000}{E_2 \times V_{\text{solution}}\,(\text{in mL})}$

Demal, $(D) = \frac{w_2 \times 1000}{M_2 \times V_{\text{solution}}\,(\text{in mL})}$ (at 0°C)

Mole fraction, $(x) \Rightarrow x_1 = \frac{n_1}{n_1 + n_2}$ or $x_2 = \frac{n_2}{n_1 + n_2}$, and $x_1 + x_2 = 1$

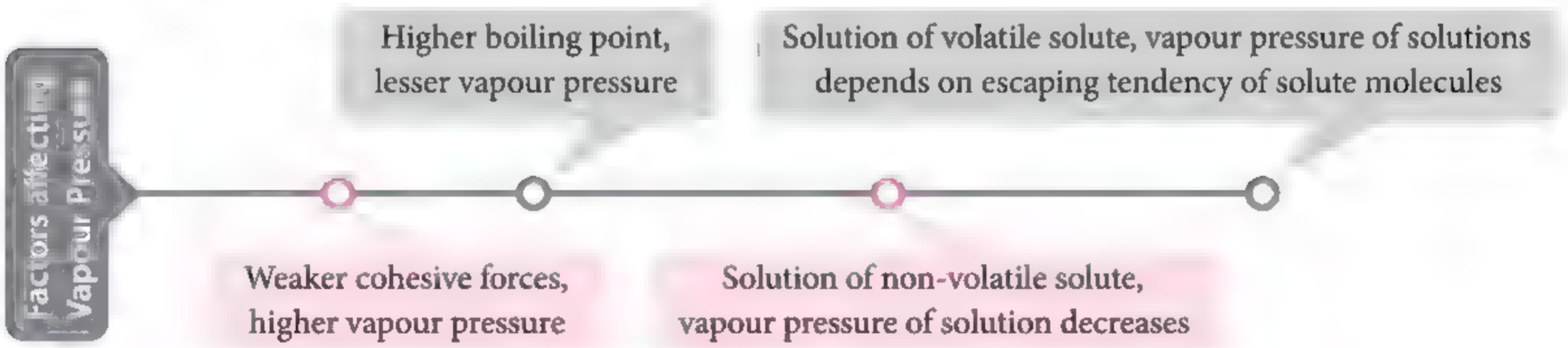
Formality, $(F) = \frac{\text{No. of gram formula mass of solute}}{\text{Volume of solution (in L)}}$

## Vapour Pressure

*Vapour pressure* is the pressure exerted by the vapours over the solution when it is in equilibrium state at a given temperature.

$$\log\frac{P_2}{P_1} = \frac{\Delta_{vap}H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right] \qquad \text{(Clausius–Clapeyron equation)}$$

where $P_1$ and $P_2$ are the vapour pressures at temperatures $T_1$ and $T_2$ respectively.




*Raoult's law* states that for a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction in the solution.

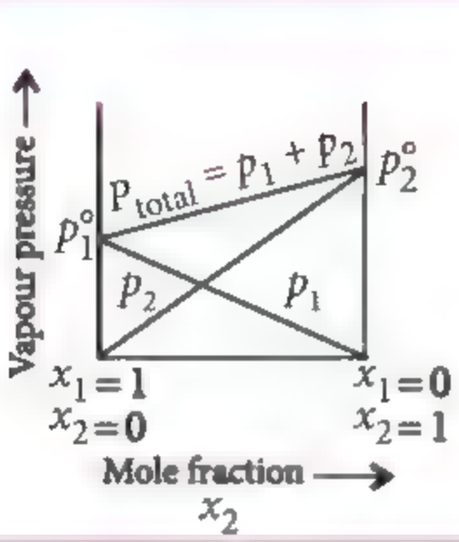
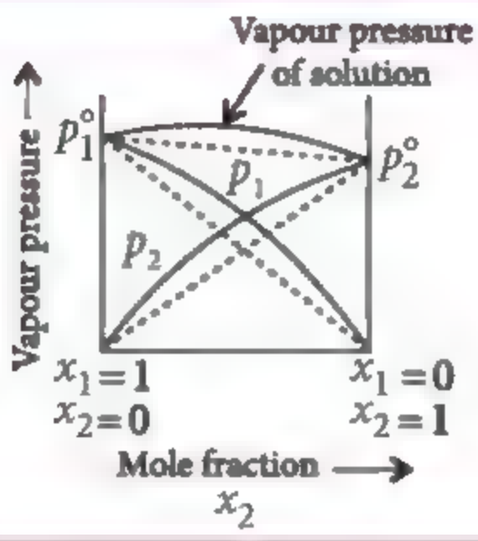
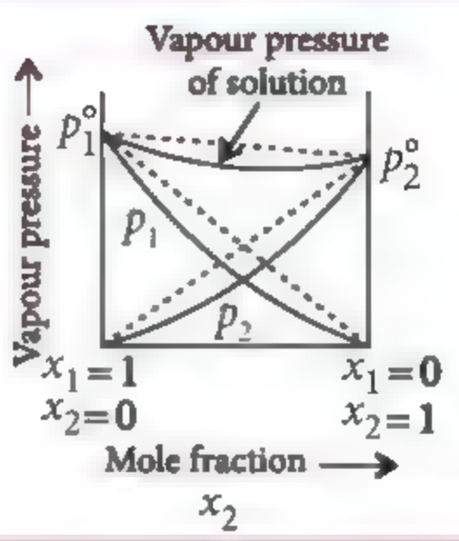
For component 1, $p_1 = p_1^\circ x_1$

For component 2, $p_2 = p_2^\circ x_2$

$$P_{\text{total}} = p_1 + p_2 = x_1p_1^\circ + x_2p_2^\circ = p_1^\circ + (p_2^\circ - p_1^\circ)x_2$$

where $p_1^\circ$ and $p_2^\circ$ are the vapour pressures of pure components 1 and 2 respectively.

## Ideal and Non-ideal Solutions

| Ideal solutions | Non-ideal solutions | |
|---|---|---|
| | Positive deviation from Raoult's law | Negative deviation from Raoult's law |
|  |  |  |
| $A - B$ interactions $\approx$ $A - A$ and $B - B$ interactions | $A - B$ interactions $<<$ $A - A$ and $B - B$ interactions | $A - B$ interactions $>>$ $A - A$ and $B - B$ interactions |
| $\Delta H_{mix} = 0$, $\Delta V_{mix} = 0$ | $\Delta H_{mix} > 0$, $\Delta V_{mix} > 0$ | $\Delta H_{mix} < 0$, $\Delta V_{mix} < 0$ |
| *e.g.*, dilute solution, benzene + toluene, *n*-hexane + *n*-heptane | *e.g.*, acetone + ethanol, acetone + $CS_2$, water + methanol | *e.g.*, acetone + aniline, acetone + chloroform, $CH_3OH + CH_3COOH$ |

## Azeotropes

- *Azeotropes* have the same composition in liquid and vapour phase and boil at a constant temperature. Their components cannot be separated by fractional distillation. Minimum boiling azeotropes show a large positive deviation from Raoult's law *e.g.*, ethanol-water mixture. Maximum boiling azeotropes show a large negative deviation from Raoult's law *e.g.*, nitric acid-water mixture.

## Colligative Properties

- These properties depend only on the number of solute particles and not on its nature.

### Relative Lowering of Vapour Pressure

$$\frac{p_1^\circ - p_1}{p_1^\circ} = x_2 = \frac{n_2}{n_1 + n_2} = \frac{n_2}{n_1} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

($\because$ for dilute solutions, $n_2 << n_1$)

### Depression in Freezing Point

$\Delta T_f = T_f^\circ - T_f$; $\Delta T_f \propto m$ or $\Delta T_f = K_f m$

$$= K_f \left( \frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} \right)$$

$K_f$ is known as freezing point depression constant or molal depression constant or Cryoscopic constant, having unit K kg $mol^{-1}$.

### Elevation in Boiling Point

$\Delta T_b = T_b - T_b^\circ$;

$$\Delta T_b \propto m \text{ or } \Delta T_b = K_b m = K_b \left( \frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} \right)$$

$K_b$ is called boiling point elevation constant or molal elevation constant or Ebullioscopic constant, having unit K kg $mol^{-1}$.

### Osmotic Pressure

$$\pi = CRT = \left( \frac{n_2}{V} \right) RT,$$

$$\pi V = \frac{w_2 RT}{M_2} \text{ or } M_2 = \frac{w_2 RT}{\pi V}$$

## VAN'T HOFF FACTOR

- It is defined as the ratio of the experimental value of the colligative property to the calculated value of the colligative property.

$$i = \frac{\text{Observed value of the colligative property}}{\text{Calculated value of the colligative property}}$$

$$i = \frac{\text{Calculated molecular mass}}{\text{Observed molecular mass}}$$

$$i = \frac{\text{Total number of moles of particles after association / dissociation}}{\text{Total number of moles of particles before association / dissociation}}$$

$$\alpha_{\text{dissociation}} = \frac{i-1}{n-1}$$

$$\alpha_{\text{association}} = \frac{1-i}{1-\frac{1}{n}}$$

- For substances undergoing association or dissociation in the solution, the various expressions for the colligative properties are modified as follows :

$$\frac{p_1^\circ - p_1}{p_1^\circ} = ix_2; \qquad \Delta T_b = iK_b m$$

$$\Delta T_f = iK_f m; \qquad \pi = iCRT$$


**Forward Osmosis - The future process of desalination!**

Reverse osmosis (RO) process is generally employed in our domestic water purifiers for desalination of water but recently, scientists are interesting to employ forward osmosis (FO) process for desalination as it requires low energy and wastage of water is also less.

# WRAP it up!

1. In the ionic compound $AB$ the ratio $r_{A^+} : r_{B^-}$ is 0.414. Which of the following statements is correct?
   (a) Cations form close packing and anions exactly fit into the octahedral voids.
   (b) Anions form close packing and cations occupy precisely half of the tetrahedral voids.
   (c) Anions form close packing and cations occupy precisely all the octahedral voids.
   (d) Anions form close packing and cations fit into the octahedral voids loosely.

2. Two solutions of $KNO_3$ and $CH_3COOH$ are prepared separately. Molarity of both is 0.1 M and osmotic pressures are $p_1$ and $p_2$ respectively. The correct relationship between the osmotic pressures is
   (a) $p_1 = p_2$ (b) $p_1 > p_2$
   (c) $p_2 > p_1$ (d) $\frac{p_1}{p_1 + p_2} \neq \frac{p_2}{p_1 + p_2}$

3. Which method cannot be used to find out the molecular weight of non-volatile solute?
   (a) Victor Meyer's method
   (b) Osmotic pressure method
   (c) Cryoscopic method
   (d) Ebullioscopic method

4. A metal crystallizes in body-centred cubic structure. The correct statement amongst the following is
   (a) each atom touches 4 atoms in its own layer and 4 each in the layers immediately above and below it
   (b) each atom touches 6 atoms each in the layers immediately above and below it and none in its own layer
   (c) each atom touches 4 atoms each in the layers immediately above and below it and none in its own layer
   (d) each atom touches 8 atoms each in the layers immediately above and below it and none in its own layer.

5. Which of the following is not a function of an impurity present in a crystal?
(a) Establishing thermal equilibrium
(b) Having tendency to diffuse
(c) Contribution in scattering
(d) Introducing new electronic energy levels.

6. A solution at 20°C is composed of 1.5 mol of benzene and 3.5 mol of toluene. If the vapour pressure of pure benzene and pure toluene at this temperature are 74.7 torr and 22.3 torr, respectively, then the total vapour pressure of the solution and the benzene mole fraction in equilibrium with it will be, respectively
(a) 35.0 torr and 0.480 (b) 38.0 torr and 0.589
(c) 30.5 torr and 0.389 (d) 35.8 torr and 0.280
**(JEE Main 2015)**

7. A compound is formed by cation *C* and anion *A*. The anions form hexagonal close packed (*hcp*) lattice and the cations occupy 75% of octahedral voids. The formula of the compound is
(a) $C_4A_3$ (b) $C_2A_3$
(c) $C_3A_2$ (d) $C_3A_4$ **(NEET 2019)**

8. At 100°C the vapour pressure of a solution of 6.5 g of a solute in 100 g water is 732 mm. If $K_b = 0.52$, the boiling point of this solution will be
(a) 102°C (b) 103°C
(c) 101°C (d) 100°C **(NEET 2016)**

9. If the unit cell of a mineral has cubic close packed (*ccp*) array of oxygen atoms with *m* fraction of octahedral holes occupied by aluminium ions and *n* fraction of tetrahedral holes occupied by magnesium ions, *m* and *n*, respectively, are
(a) $\frac{1}{2}, \frac{1}{8}$ (b) $1, \frac{1}{4}$
(c) $\frac{1}{2}, \frac{1}{2}$ (d) $\frac{1}{4}, \frac{1}{8}$
**(JEE Advanced 2016)**

10. Calculate the mass of a non-volatile solute (molar mass 40 g $mol^{-1}$) which should be dissolved in 114 g octane to reduce its vapour pressure to 80%.
(a) 20 g (b) 10 g
(c) 30 g (d) 45 g

11. The vapour pressures of pure liquids *A* and *B* are 400 and 600 mmHg, respectively at 298 K. On mixing the two liquids, the sum of their initial volumes is equal to the volume of the final mixture. The mole fraction of liquid *B* is 0.5 in the mixture. The vapour pressure of the final solution, the mole fractions of components *A* and *B* in vapour phase, respectively are
(a) 450 mmHg, 0.5, 0.5 (b) 450 mmHg, 0.4, 0.6
(c) 500 mmHg, 0.5, 0.5 (d) 500 mmHg, 0.4, 0.6
**(JEE Main 2019)**

12. Based upon the technique of reverse osmosis, the approximate pressure required to desalinate sea water containing 2.5% (mass/volume) NaCl at 27°C will be
(a) 10.5 atm (b) 21 atm
(c) 2.1 atm (d) 1.05 atm

13. Sodium metal crystallizes in a body centred cubic lattice with a unit cell edge of 4.29 Å. The radius of sodium atom is approximately
(a) 5.72 Å (b) 0.93 Å
(c) 1.86 Å (d) 3.22 Å
**(JEE Main 2015)**

14. Two moles of a liquid $A$ ($p^\circ_A = 100$ torr) and 3 moles of liquid $B$ ($p^\circ_B = 150$ torr) form a solution having vapour pressure of 120 torr. Based upon this observation which of the following is correct?
(a) Interactions between like molecules > those between unlike molecules
(b) Interactions between like molecules < those between unlike molecules
(c) Interaction between like molecules = those between unlike molecules
(d) Nothing can be concluded.

15. Lithium has a *bcc* structure. Its density is 530 kg $m^{-3}$ and its atomic mass is 6.94 g $mol^{-1}$. Calculate the edge length of a unit cell of lithium metal. ($N_A = 6.02 \times 10^{23}$ $mol^{-1}$)
(a) 527 pm (b) 264 pm
(c) 154 pm (d) 352 pm **(NEET 2016)**

16. An alloy of copper, silver and gold is found to have cubic lattice in which Cu atoms constitute *ccp*. If Ag atoms are located at the edge centres and Au atom is present at body centre, the alloy will have the formula
(a) CuAgAu (b) $Cu_4Ag_4Au$
(c) $Cu_4Ag_3Au$ (d) $Cu_4Ag_6Au$

17. The vapour pressure of acetone at 20°C is 185 torr. When 1.2 g of a non-volatile substance was dissolved in 100 g of acetone at 20°C, its vapour pressure was 183 torr. The molar mass (g $mol^{-1}$) of the substance is
(a) 128 (b) 488
(c) 32 (d) 64 **(JEE Main 2015)**

18. Ferrous oxide has a cubic structure and each edge of the unit cell is 5.0 Å. Assuming density of the oxide as 4.09 g $cm^{-3}$ the number of $Fe^{2+}$ and $O^{2-}$ ions presents in each unit cell will be
(a) two $Fe^{2+}$ and four $O^{2-}$
(b) three $Fe^{2+}$ and three $O^{2-}$
(c) four $Fe^{2+}$ and two $O^{2-}$
(d) four $Fe^{2+}$ and four $O^{2-}$.

19. The ionic radii of $A^+$ and $B^-$ ions are $0.98 \times 10^{-10}$ m and $1.81 \times 10^{-10}$ m. The coordination number of each ion in $AB$ is
(a) 8 (b) 2
(c) 6 (d) 4 **(NEET 2016)**

20. The vapour pressure of a liquid decreases by 10 torr when a non-volatile solute is dissolved. The mole fraction of the solute in solution is 0.1. What would be the mole fraction of the liquid if the decrease in vapour pressure is 20 torr when the solute being dissolved is same?
(a) 0.2 (b) 0.9
(c) 0.8 (d) 0.6

21. Determination of the molar mass of acetic acid in benzene using freezing point depression is affected by
(a) dissociation (b) association
(c) partial ionization (d) complex formation.
**(JEE Main 2015)**

22. The flame colours of metal ions are due to
(a) Schottky defect (b) Frenkel defect
(c) metal excess defect
(d) metal deficiency defect.

23. Which of the following statements about the composition of the vapour over an ideal 1 : 1 molar mixture of benzene and toluene is correct? Assume that the temperature is constant at 25°C. (Given, vapour pressure data at 25°C, benzene = 12.8 kPa, toluene = 3.85 kPa)
(a) The vapour will contain equal amounts of benzene and toluene.
(b) Not enough information is given to make a prediction.
(c) The vapour will contain a higher percentage of benzene.
(d) The vapour will contain a higher percentage of toluene. **(NEET 2016)**

24. CsCl crystallises in body-centred cubic lattice. If '$a$' is its edge length then which of the following expressions is correct?
(a) $r_{Cs^+} + r_{Cl^-} = \sqrt{3}a$ (b) $r_{Cs^+} + r_{Cl^-} = 3a$
(c) $r_{Cs^+} + r_{Cl^-} = \frac{3a}{2}$ (d) $r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$
**(JEE Main 2014)**

25. A mineral $MX_2$ crystallizes in *ccp* of $M^{2+}$ ions whereas $X^-$ ions occupy the tetrahedral voids. The number of cations and anions per unit cell, the coordination number of cation and percent of tetrahedral voids occupied are
(a) 4, 8, 8, 100% (b) 4, 8, 8, 50%
(c) 8, 4, 8, 50% (d) 8, 4, 8, 100%

26. The correct statement regarding defects in crystalline solids is
(a) Frenkel defects decrease the density of crystalline solids.
(b) Frenkel defect is a dislocation defect.
(c) Frenkel defect is found in halides of alkaline metals.
(d) Schottky defects have no effect on the density of crystalline solids. **(AIPMT 2015)**

27. For the determination of molecular weights, Raoult's law is applicable only to
(a) dilute solutions of electrolytes
(b) concentrated solutions of electrolytes
(c) dilute solutions of non-electrolytes
(d) concentrated solutions of non-electrolytes.

28. What is the mole fraction of the solute in a 1.00 m aqueous solution?
(a) 1.770 (b) 0.0354
(c) 0.0177 (d) 0.177 **(AIPMT 2015)**

29. A flask is partially evacuated to 400 torr pressure of air. A small amount of benzene is introduced into the flask in order that some liquid will remain after equilibrium has been established. The vapour pressure of benzene at 25°C is 220 torr. What is the total pressure in the flask at equilibrium at 25°C?
(a) 120 torr (b) 510 torr
(c) 620 torr (d) 480 torr.

30. A dry air is passed through the solution, containing the 10 g of solute and 90 g of water and then it is passed through pure water. There is the depression in weight of solution by 2.5 g and in weight of pure solvent by 0.05 g. Calculate the molecular weight of solute.
(a) 25 (b) 50
(c) 100 (d) 180

## SOLUTIONS

1. **(c) :** For the octahedral void, $r_{void}/r_{anion} = 0.414$

2. **(b) :** $KNO_3$ dissociates completely while $CH_3COOH$ dissociates to a small extent hence, $p_1 > p_2$.

3. **(a) :** Victor Meyer's method is used for volatile solutes and the rest all other methods are used for non-volatile solutes.

4. **(c)**

5. **(a) :** Addition of impurity does not establish equilibrium.

6. **(b) :** Total vapour pressure of solution $= p^\circ_A x_A + p^\circ_B x_B$

Total vapour pressure of solution

$$= \left(\frac{1.5}{5}\times 74.7 + \frac{3.5}{5}\times 22.3\right) \text{ torr}$$

$$= (22.41 + 15.61) \text{ torr} = 38.02 \text{ torr}$$

$$\text{Mole fraction of benzene in vapour form} = \frac{22.41}{38.02} = 0.589$$

7. **(d) :** Number of atoms per unit cell in *hcp* = 6

Number of octahedral void in *hcp* = 6

Number of anions per unit cell = 6

Number of octahedral voids occupied by cations

$$= 6\times\frac{75}{100} = \frac{9}{2}$$

$\therefore$ Formula of compound = $C_3A_4$

8. **(c) :** Given : $W_B = 6.5$ g, $W_A = 100$ g, $p_s = 732$ mm, $K_b = 0.52$, $T^\circ_b = 100°C$, $p^\circ = 760$ mm

$$\frac{p^\circ - p_s}{p^\circ} = \frac{n_2}{n_1} \Rightarrow \frac{760-732}{760} = \frac{n_2}{100/18}$$

$$\Rightarrow \quad n_2 = \frac{28\times 100}{760\times 18} = 0.2046 \text{ moles}$$

$$\Delta T_b = K_b \times m$$

$$T_b - T^\circ_b = K_b \times \frac{n_2 \times 1000}{W_A(\text{g})}$$

$$T_b - 100°C = \frac{0.52\times 0.2046\times 1000}{100} = 1.06$$

$$T_b = 100 + 1.06 = 101.06°C$$

9. **(a) :** For *ccp*, $Z = 4$ = no. of O atoms

No. of octahedral voids = 4

No. of tetrahedral voids = $2 \times 4 = 8$

No. of $Al^{3+}$ ions = $m \times 4$

No. of $Mg^{2+}$ ions = $n \times 8$

Thus, the formula of the mineral is $Al_{4m}\, Mg_{8n} O_4$.

$4m\,(+3) + 8n(+2) + 4(-2) = 0$

$12m + 16n - 8 = 0 \Rightarrow 4(3m + 4n - 2) = 0$

$3m + 4n = 2$

Possible values of $m$ and $n$ are $\frac{1}{2}$ and $\frac{1}{8}$ respectively.

10. **(b) :** According to Raoult's law, relative lowering of vapour pressure,

$$\frac{p^\circ_A - p_s}{p^\circ_A} = x_B \qquad \ldots(i)$$

$$x_B = \frac{n_B}{n_B + n_A} = \frac{W_B/M_B}{\frac{W_B}{M_B} + \frac{W_A}{M_A}} \qquad \ldots(ii)$$

Given vapour pressure is reduced to 80% when non-volatile solute is dissolved in octane *i.e.*, if $p^\circ_A = 1$ atm then $p_s = 0.8$ atm; $p^\circ_A - p_s = 0.2$ atm;

$M_A(C_8H_{18}) = 114$ g mol$^{-1}$; $W_A = 114$ g;

$M_B = 40$ g mol$^{-1}$; $W_B = ?$

From eq. (i) and (ii),

$$\frac{0.2}{1} = \frac{W_B/40}{\frac{W_B}{40} + \frac{114}{114}} = \frac{W_B/40}{\frac{W_B}{40} + 1} \Rightarrow 0.2 = \frac{W_B}{W_B + 40}$$

$$0.2W_B + 8 = W_B \Rightarrow W_B = 10$$

11. **(d) :** According to Raoult's law : $P = P^\circ_A X_A + P^\circ_B X_B$

If $X_B = 0.5$ then $X_A = 1 - 0.5 = 0.5$

$P^\circ_A = 400$ mmHg ; $P^\circ_B = 600$ mmHg

$P = 0.5\,(400) + 0.5\,(600) = 200 + 300 = 500$ mmHg

Mole fraction in vapour phase can be given as

$$Y_A = \frac{X_A P^\circ_A}{P} = \frac{0.5\times 400}{500} = 0.4 \ ;$$

$$Y_B = \frac{X_B P^\circ_B}{P} = \frac{0.5\times 600}{500} = 0.6$$

12. **(b) :** 2.5% (mass/volume) NaCl means 2.5 g NaCl in 100 mL of water.

$$\text{Thus, } \pi = iCRT = \frac{2\times 2.5\times 1000\times 0.082\times 300}{58.5\times 100} = 21.02 \text{ atm}$$

13. **(c) :** For *bcc*, $r = \frac{\sqrt{3}}{4}a$ ; $r = \frac{\sqrt{3}}{4}\times 4.29 = 1.86$ Å

14. **(b) :** Total vapour pressure

$$= p^\circ_A x_A + p^\circ_B x_B = 100\times\frac{2}{5} + 150\times\frac{3}{5} = 130 \text{ torr}$$

The observed vapour pressure is smaller than that calculated from Raoult's law (negative deviation). Hence, interactions $A - B > A - A$ or $B - B$.

15. **(d) :** For *bcc*, $Z = 2$, $\rho = 530$ kg m$^{-3}$,

At. mass of Li = 6.94 g mol$^{-1}$, $N_A = 6.02 \times 10^{23}$ mol$^{-1}$

$$\rho = 530 \text{ kg m}^{-3} = \frac{530\times 1000 \text{ g}}{1\times(100)^3 \text{ cm}^3} = 0.53 \text{ g cm}^{-3}$$

$$\rho = \frac{Z \times \text{At. mass}}{N_A \times a^3}$$

$$a^3 = \frac{Z \times \text{At. mass}}{N_A \times \rho} = \frac{2 \times 6.94}{6.02 \times 10^{23} \times 0.53}$$

$a^3 = 4.35 \times 10^{-23}\ \text{cm}^3 = 43.5 \times 10^{-24}\ \text{cm}^3$

$a = 352 \times 10^{-10}\ \text{cm} = 352\ \text{pm}$

**16. (c) :** Number of Cu atoms per unit cell

$$= \frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 4$$

Number of Ag atoms per unit cell $= \frac{1}{4} \times 12 = 3$

Number of Au atoms per unit cell = 1(at body centre)

Hence, the formula of alloy is $Cu_4Ag_3Au$.

**17. (d) :** $\frac{p^\circ - p_s}{p^\circ} = \frac{w_2 M_1}{w_1 M_2}$

Given : $p^\circ$ = 185 torr, $w_1$ = 100 g, $w_2$ = 1.2 g, $p_s$ = 183 torr

$M_1 = M_{CH_3COCH_3} = 58\ \text{g mol}^{-1}$

$$\frac{185 - 183}{185} = \frac{1.2 \times 58}{100 \times M_2}$$

$$\Rightarrow \quad M_2 = \frac{1.2 \times 58 \times 185}{100 \times 2} = 64.38 \approx 64\ \text{g mol}^{-1}$$

**18. (d):** Let the units of ferrous oxide in a unit cell = $n$.

Molecular weight of ferrous oxide (FeO)

$= 56 + 16 = 72\ \text{g mol}^{-1}$

$$\text{Weight of } n \text{ units} = \frac{72 \times n}{6.023 \times 10^{23}}$$

$$\text{Density} = \frac{\text{Wt. of cell}}{\text{Volume}}$$

$$4.09 = \frac{72 \times n}{6.023 \times 10^{23} \times 125 \times 10^{-24}}$$

Hence , $n = 4.27 \approx 4$

**19. (c) :** Radius ratio, $\frac{r_+}{r_-} = \frac{0.98 \times 10^{-10}}{1.81 \times 10^{-10}} = 0.541$

It lies in the range of 0.414 to 0.732 hence, coordination number of each ion will be 6 as the compound will have NaCl type structure.

**20. (c) :** $\frac{\Delta p_1}{\Delta p_2} = \frac{x_{1(\text{solute})}}{x_{2(\text{solute})}}$, $x_{2(\text{solute})} = \frac{20}{10} \times 0.1 = 0.2$;

$x_{\text{solvent}} = 1 - 0.2 = 0.8$

**21. (b)** **22. (c)**

**23. (c) :** $p_{\text{Benzene}} = x_{\text{Benzene}}\, p^\circ_{\text{Benzene}}$

$p_{\text{Toluene}} = x_{\text{Toluene}}\, p^\circ_{\text{Toluene}}$

For an ideal 1 : 1 molar mixture of benzene and toluene,

$$x_{\text{Benzene}} = \frac{1}{2} \text{ and } x_{\text{Toluene}} = \frac{1}{2}$$

$$p_{\text{Benzene}} = \frac{1}{2} p^\circ_{\text{Benzene}} = \frac{1}{2} \times 12.8\ \text{kPa} = 6.4\ \text{kPa}$$

$$p_{\text{Toluene}} = \frac{1}{2} p^\circ_{\text{Toluene}} = \frac{1}{2} \times 3.85\ \text{kPa} = 1.925\ \text{kPa}$$

Thus, the vapour will contain a high percentage of benzene as the partial vapour pressure of benzene is higher as compared to that of toluene.

**24. (d):** In a body-centred cubic (*bcc*) lattice, oppositely charged ions touch each other along the cross-diagonal of the cube.

In case of CsCl,

$$2r_{Cs^+} + 2r_{Cl^-} = \sqrt{3}a \text{ or, } r_{Cs^+} + r_{Cl^-} = \frac{\sqrt{3}}{2}a$$

**25. (a) :** $M^{2+}$ ions in *ccp* arrangement has 4 atoms per unit cell. Now, for $MX_2$ type salt, number of $X^-$ ions per unit cell is 8. Also, the number of tetrahedral voids for *ccp* arrangement is 8 so, $X^-$ ions occupy 100% of tetrahedral voids. $MX_2$ type salt with such arrangement is a fluorite type structure in which coordination number for cations is 8 and for anions is 4.

**26. (b)** **27. (c)**

**28. (c) :** 1 molal aqueous solution means 1 mole of solute is present in 1000 g of water.

$$\therefore \quad x_{\text{solute}} = \frac{1}{1 + \frac{1000}{18}} = \frac{1}{56.5} = 0.0177$$

**29. (c) :** The total pressure will be the sum of pressures of air and benzene.

**30. (c) :** $\because$ Lowering in weight of solution $\propto$ solution pressure ($p_s$)

and lowering in weight of solvent $\propto p^\circ - p_s$

($\because$ $p^\circ$ = vapour pressure of pure solvent)

$$\text{Thus, } \frac{p^\circ - p_s}{p_s} = \frac{\text{Lowering in weight of solvent}}{\text{Lowering in weight of solution}} = \frac{0.05}{2.5}$$

But according to Raoult's law,

$$\frac{p^\circ - p_s}{p_s} = \frac{W_2}{M_2} \times \frac{M_1}{W_1}$$

$$\therefore \quad \frac{0.05}{2.5} = \frac{10 \times 18}{90 \times M_2} \Rightarrow M_2 = \frac{10 \times 18 \times 2.5}{90 \times 0.05} = 100\ \text{g mol}^{-1}$$

# GET SET GO for NEET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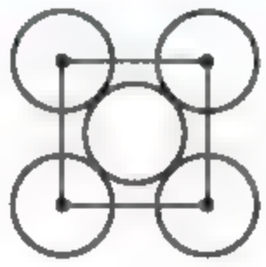
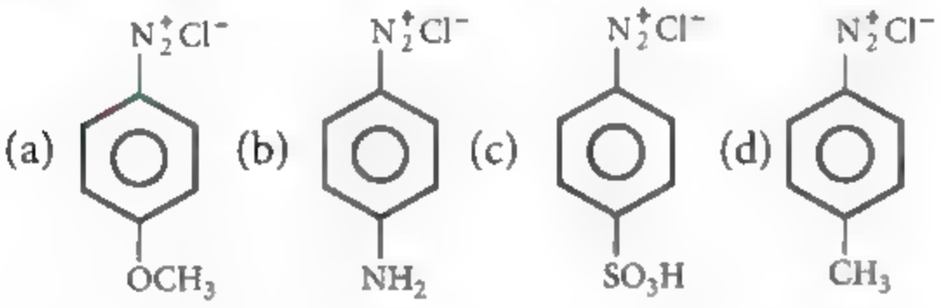
Practicing these MCQs help to strengthen your concepts and give you extra edge in your NEET preparation

1. The packing efficiency of the two dimensional square unit cell shown below is



(a) 50.25%
(b) 68.0 2%
(c) 74.05%
(d) 78.50%

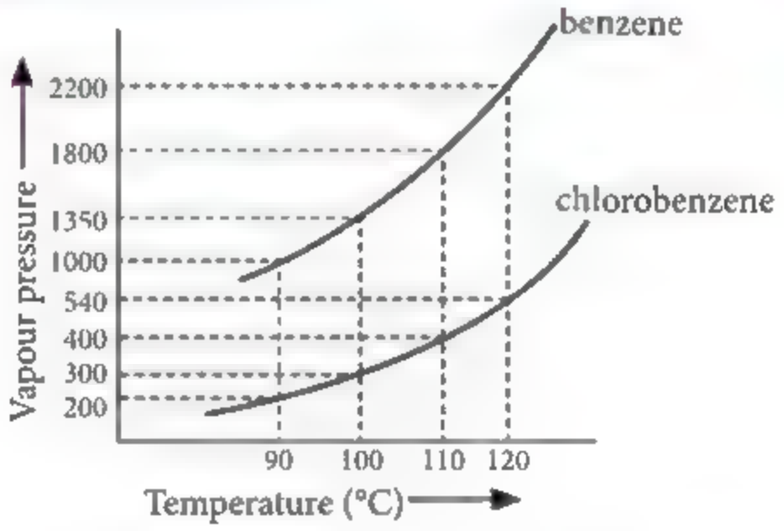
2. Which of the following compounds is most suitable for diazo coupling reaction?




3. In which of the following reactions coloured gas is a product?
(a) $H_3PO_3 \xrightarrow{\Delta}$
(b) $O_3 + KI \xrightarrow{\text{Neutral solution}}$
(c) $HBr + H_2SO_4$ (conc.) $\longrightarrow$
(d) All of these

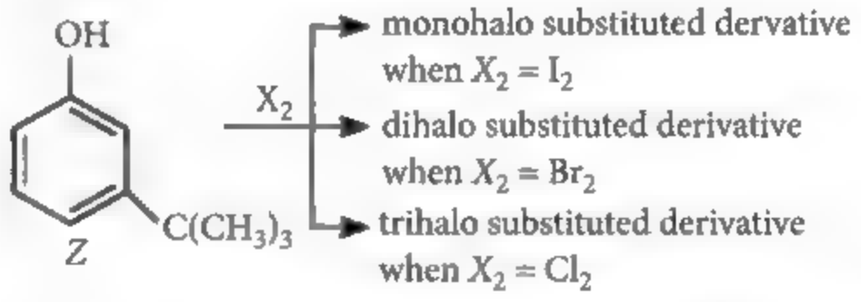
4. An aqueous solution freezes at –0.186 °C ($K_f$ = 1.86, $K_b$ = 0.512). What is the elevation in boiling point?
(a) 0.512 (b) 0.0512
(c) 0.186 (d) 0.0186

5. Assuming the formation of an ideal solution, determine the boiling point of a mixture containing 1560 g benzene and 1125 g chlorobenzene using the following graph against an external pressure of 1000 torr.



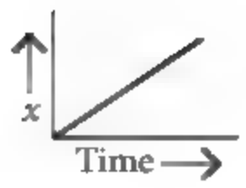

(a) 120 °C (b) 110 °C (c) 100 °C (d) 90 °C

6. The reactivity of compound *Z* with different halogens under appropriate conditions is given below

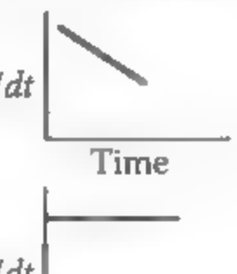



The observed pattern of electrophilic substitution cannot be explained by
(a) the steric effect of the halogen
(b) the steric effect of the *tert*-butyl group
(c) the electronic effect of the phenolic group
(d) the electronic effect of the *tert*-butyl group.

7. Graph between concentration of the product and time of the reaction ($A \rightarrow B$) is shown as :




Then, graph between $-d[A]/dt$ and time will be of the type

(a) 


(b) 


(c) 


(d) 

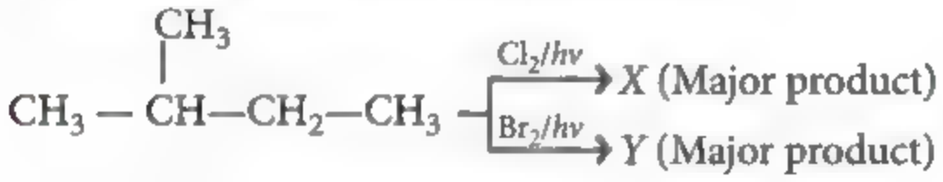

8. Which of the following gives three mole of AgBr with excess $AgNO_3$ solution?
   (a) $[Co(NH_3)_6]Br_3$ (b) $[Co(NH_3)_3Br_3]$
   (c) $[Co(NH_3)_4Br_2]Br$ (d) $[Co(NH_3)_5Br]Br_2$

9. 0.1 molar NaCl solution is filled in different conductivity cells.

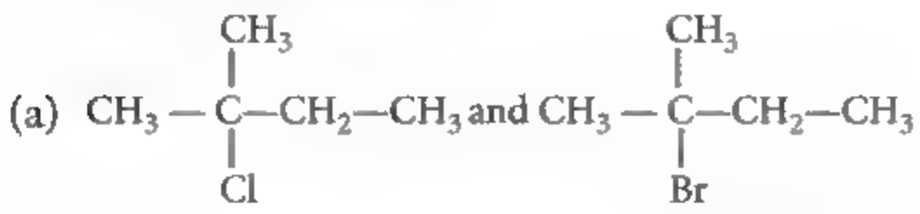
| | **Cell – 1** | **Cell – 2** | **Cell – 3** |
|---|---|---|---|
| Area of cross section ($A$) | 5 $cm^2$ | 7.5 $cm^2$ | 10 $cm^2$ |
| Distance between two electrodes ($l$) | 2 cm | 3 cm | 4 cm |

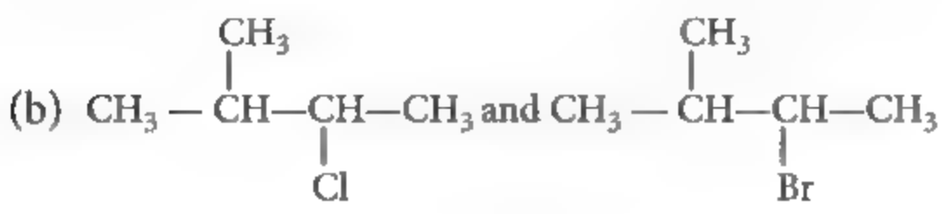
Order of equivalent conductance of NaCl solution is
   (a) Cell – 1 > Cell – 2 > Cell – 3
   (b) Cell – 1 = Cell – 2 = Cell – 3
   (c) Cell – 1 > Cell – 3 > Cell – 2
   (d) Cell – 3 > Cell – 2 > Cell – 1

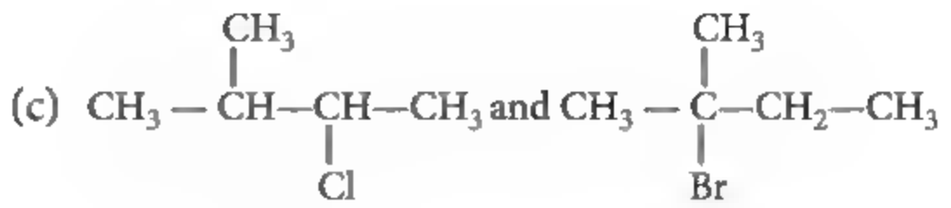
10. A mineral is called ore if
   (a) metal present in the mineral is costly
   (b) a metal can be extracted from it
   (c) a metal can be extracted profitably from it
   (d) a metal cannot be extracted from it.

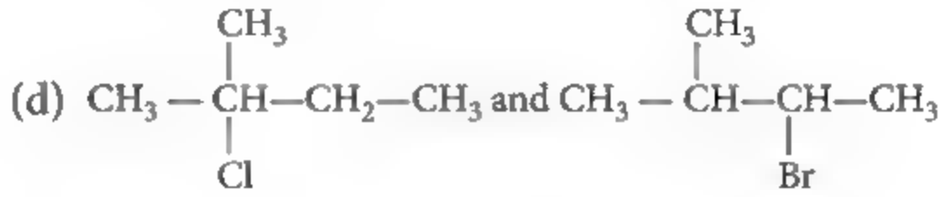
11. 


$X$ and $Y$ are respectively

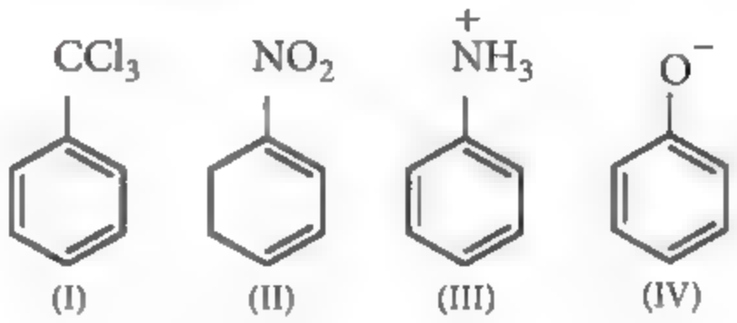
(a) 


(b) 


(c) 

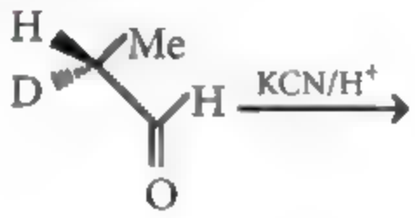

(d) 


12. In which of the following, $NO_2^+$ will attack at *m*-position?




   (a) I, II, and III (b) II and IV
   (c) II and III only (d) I only

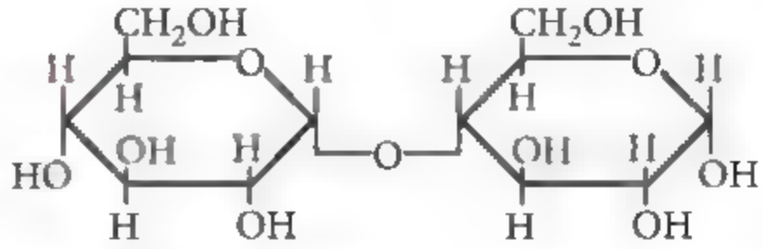
13. The number of products formed in the following reaction is

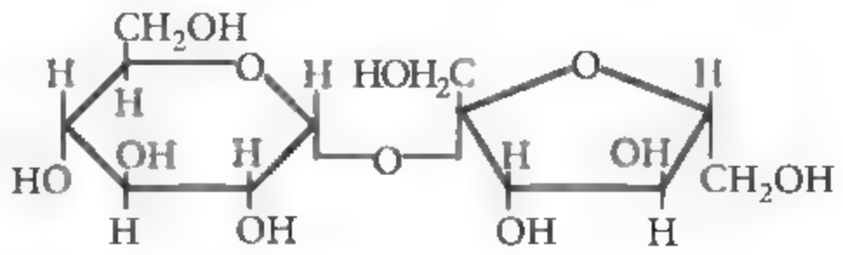


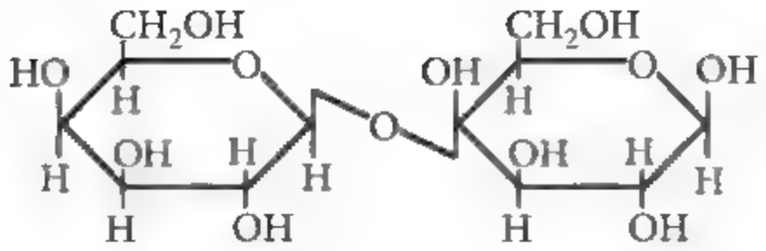

   (a) 1 (b) 2 (c) 3 (d) 4

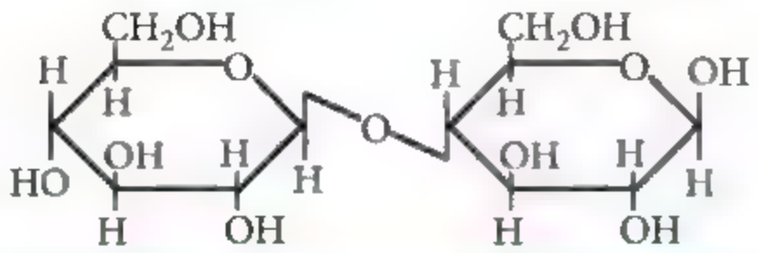
14. In acidic medium $KMnO_4$ oxidises $FeSO_4$ solution. Which of the following statements is correct?
   (a) 10 mL of 1N $KMnO_4$ solution oxidises 10 mL of 5N $FeSO_4$ solution.
   (b) 10 mL of 1M $KMnO_4$ solution oxidises 10 mL of 5N $FeSO_4$ solution.
   (c) 10 mL of 1M $KMnO_4$ solution oxidises 10 mL of 1M $FeSO_4$ solution.
   (d) 10 mL of 1N $KMnO_4$ solution oxidises 10 mL of 0.1M $FeSO_4$ solution.

15. Which of the following disaccharides is non-reducing in nature?

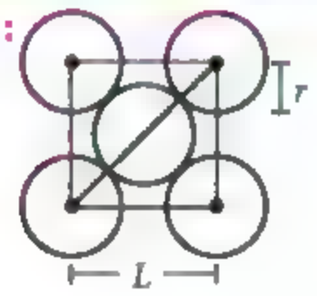
(a) 


(b) 

(c) 

(d) 

## SOLUTIONS

1. **(d) :** 

$4r = L\sqrt{2}$ so, $L = 2\sqrt{2}r$

Area of square unit cell = $(2\sqrt{2}r)^2 = 8r^2$

Area of atoms present in one unit cell

$= \pi r^2 + 4\left(\frac{\pi r^2}{4}\right) = 2\pi r^2$

so, packing efficiency = $\frac{2\pi r^2}{8r^2} \times 100$

$= \frac{\pi}{4} \times 100 = 78.5\%$

2. **(c) :** The aryl diazonium ion ($ArN_2^+$) functions as electrophile, so presence of electron withdrawing group ($-SO_3H$) increases its electrophilicity. Diazocoupling is possible only in strongly activated rings.

3. **(c) :** $4H_3PO_3 \xrightarrow{\Delta} 3H_3PO_4 + PH_3$

$2I^- + H_2O + O_3 \longrightarrow 2OH^- + I_{2(s)} + O_{2(g)}$

$HBr + H_2SO_4 \longrightarrow Br_{2(g)} + SO_2 + H_2O$

(Reddish brown)

4. **(b) :** $\Delta T_f = K_f \times m$

or, $0.186 = 1.86 \times m$ or $m = 0.1$

$\Delta T_b = K_b \times m = 0.512 \times 0.1 = 0.0512$

5. **(c) :** Moles of benzene ($n_B$) = $\frac{1560}{78} = 20$

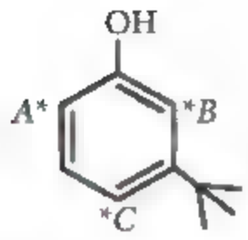
Moles of chlorobenzene ($n_C$) = $\frac{1125}{112.5} = 10$

$X_B = \frac{2}{3}, X_C = \frac{1}{3}$

At $t = 100\ ^\circ C$

$P_s = p_B^\circ X_B + p_C^\circ X_C$

$P_s = 1350 \times \frac{2}{3} + 300 \times \frac{1}{3} = 1000$ torr

6. **(d) :** 

—OH group is strongly activating and *o*/*p*-directing due to its powerful +*M* effect.

With $I_2$ only *A* is substituted, since I is large and also steric inhibition by large $-CMe_3$ group forbids substitution at *B* or *C*.

$Br_2$ and $Cl_2$ become progressively more reactive, due to

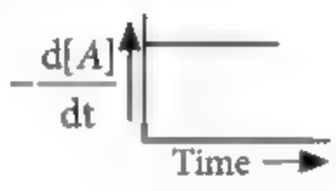
(i) Increasing electrophilic nature of $X^+$ (not mentioned in any option).

(ii) Smaller size, most sterically hindered location is *B* which is substituted only by –Cl.

7. **(c) :** From given graph $x = kt$

*i.e.*, it is a zero order reaction.

$\therefore \quad -\frac{d[A]}{dt} = k$




8. **(a) :** $[Co(NH_3)_6]Br_3 \overset{aq.}{\rightleftharpoons} [Co(NH_3)_6]^{3+} + 3Br^-$

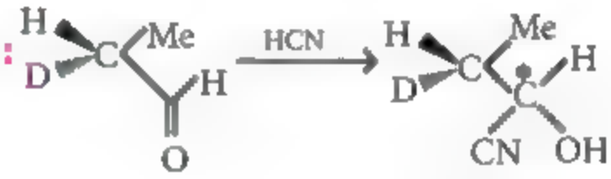
$3Ag^+ + 3Br^- \longrightarrow 3AgBr \downarrow$ (yellow)

9. **(b) :** $\Lambda_{eq} = \frac{\kappa \times 1000}{\text{Normality}}$

and $\kappa \propto \frac{l}{A}$ $\quad \left[\frac{l}{A} = \text{cell constant}\right]$

10. **(c)** 11. **(c)**

12. **(a) :** $-CCl_3$, $-NO_2$ and $\overset{+}{N}H_3$ are *meta* directing in nature.

13. **(b) :** 


2 isomers
(Diastereomers)

14. **(b) :** $2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$

1 M $KMnO_4 \equiv 5N\ KMnO_4 \equiv 5N FeSO_4$

$\therefore \quad 10 \times 1M \equiv 10 \times 5N \equiv 10 \times 5N$

$(KMnO_4) \quad (KMnO_4) \quad (FeSO_4)$

15. **(b)**

### Monthly Test Drive CLASS XI ANSWER KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. | (a) | 2. | (d) | 3. | (d) | 4. | (d) | 5. | (d) |
| 6. | (d) | 7. | (c) | 8. | (d) | 9. | (b) | 10. | (b) |
| 11. | (d) | 12. | (b) | 13. | (b) | 14. | (a) | 15. | (d) |
| 16. | (a) | 17. | (b) | 18. | (b) | 19. | (b) | 20. | (b,c,d) |
| 21. | (b,c) | 22. | (b,c) | 23. | (b,c) | 24. | (3) | 25. | (4) |
| 26. | (4) | 27. | (b) | 28. | (c) | 29. | (c) | 30. | (c) |

# MONTHLY TEST DRIVE

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

## Haloalkanes and Haloarenes

Time Taken : 60 Min.

**NEET**

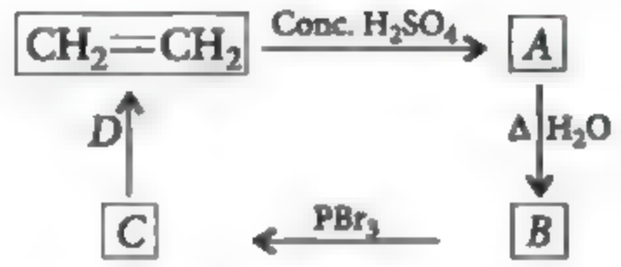
**Only One Option Correct Type**

1. In which of the following pairs, the first species is more nucleophilic than the latter?
   (a) $H_2NNH_2$, $NH_3$ (b) $HO^-$, $HOO^-$
   (c) $F^-$, $NH_2^-$ (d) $HO^-$, $HS^-$

2. Replacement of chlorine of chlorobenzene to give phenol requires drastic conditions but chlorine of 2, 4–dinitrochlorobenzene is readily replaced. This is because
   (a) $-NO_2$ makes the ring electron rich at *ortho*- and *para*- positions
   (b) $-NO_2$ withdraws $e^-$ from *meta*-position
   (c) $-NO_2$ donates $e^-$ at *meta*-position
   (d) $-NO_2$ withdraws $e^-$ from *ortho* and *para*-positions.

3. An alkyl halide with molecular formula $C_6H_{13}Br$ on dehydrohalogenation gave two isomeric alkenes *X* and *Y* with molecular formula $C_6H_{12}$. On reductive ozonolysis, *X* and *Y* gave four compounds $CH_3COCH_3$, $CH_3CHO$, $CH_3CH_2CHO$ and $(CH_3)_2CHCHO$. The alkyl halide is
   (a) 2, 2-dimethyl-1-bromobutane
   (b) 4-bromo-2-methylpentane
   (c) 2-bromo-2, 3-dimethylbutane
   (d) 3-bromo-2-methylpentane.

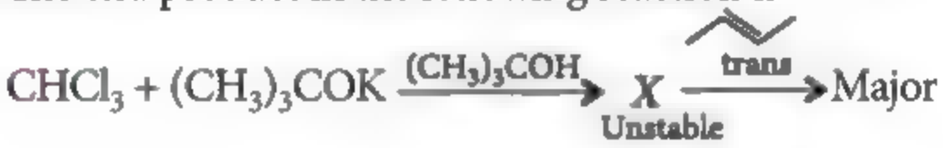
4. Identify B and D in the following sequence of reactions.

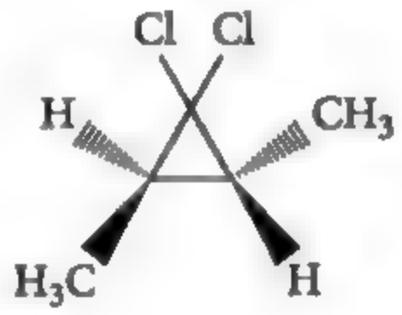
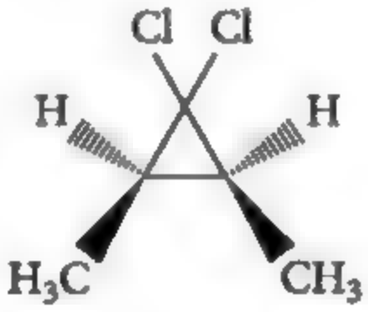



   (a) Methanol and bromoethane
   (b) Ethyl hydrogen sulphate and alcoholic KOH
   (c) Ethyl hydrogen sulphate and aqueous KOH
   (d) Ethanol and alcoholic KOH

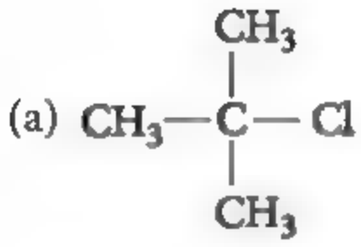
5. The fire extinguisher pyrene contains
   (a) $CO_2$ (b) $CS_2$
   (c) $CCl_4$ (d) $CHCl_3$

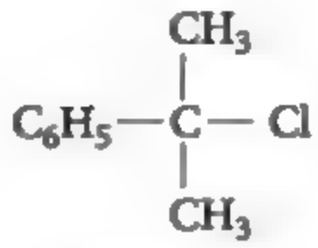
6. The end product in the following reaction is




   (a) 
   (b) 
   (c) 
   (d) 

7. For the given reaction,
   $R - Cl + NaI \xrightarrow{\text{Acetone}} R - I + NaCl$
   Which of the following alkyl halides will give the maximum yield?

(a)  (b) $CH_3—CH_2—CH_2—Cl$

(c) $C_6H_5—CH(CH_3)—Cl$ (d) 

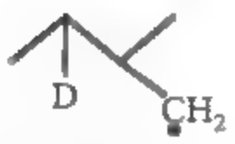
8. $CH_3C{\equiv}CH \xrightarrow[(HgSO_4)]{\text{dil. } H_2SO_4} (B) \xrightarrow[(NaOH)]{CHCl_3} (C)$

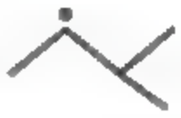
Compound (*C*) can be used as

(a) an anaesthetic (b) an insecticide
(c) a solvent (d) a hypnotic.

9. In this given reaction the major intermediate '*X*' is

$CH_3—\underset{D}{CH}—\underset{CH_3}{CH}—CH_3 + Br^{\bullet} \longrightarrow X + HBr$

(a)  (b) 

(c)  (d) 

10. Cyanoform is ..... than chloroform.

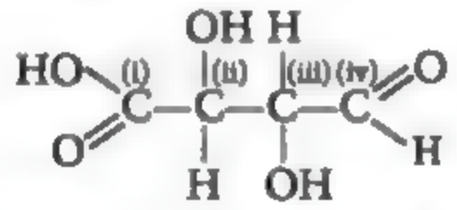
(a) weaker acid (b) weaker base
(c) stronger acid (d) stronger base

11. The products formed when alcoholic silver nitrite reacts with ethyl bromide are

1. ethyne 2. ethene
3. nitroethane 4. ethyl alcohol
5. ethyl nitrite

(a) 3, 5 (b) 3, 4 (c) 2, 3, 5 (d) 1, 5

12. Which of the carbon atoms present in the molecule given below are asymmetric?



(a) (i), (ii), (iii), (iv) (b) (ii), (iii)
(c) (i), (iv) (d) (i), (ii), (iii)

### Assertion & Reason Type

**Directions :** In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** 2-Bromobutane on reaction with sodium ethoxide in ethanol gives 1-butene as a major product.
**Reason :** 1-Butene is more stable than 2-butene.

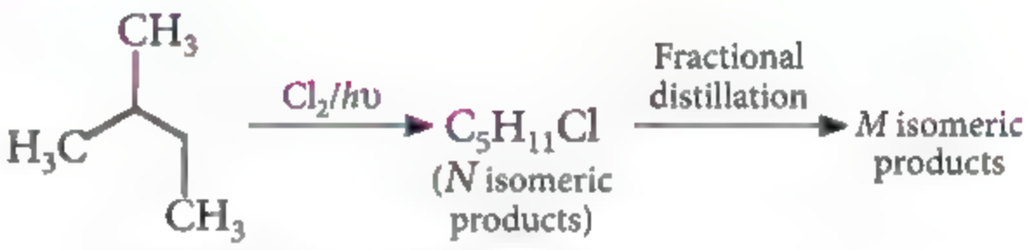
14. **Assertion :** Electron withdrawing groups in aryl halides decrease the reactivity towards nucleophilic substitution.
**Reason :** 2, 4-Dinitrochlorobenzene is less reactive than chlorobenzene towards nucleophilic substitution.

15. **Assertion :** $CH_3\underset{Cl}{C}HCH_2CH_3 \xrightarrow{\text{alc. KOH}} CH_3CH{=}CHCH_3 + KCl + H_2O$

Dehydrohalogenation reaction of 2-chlorobutane gives 2-butene.
**Reason :** Elimination reaction takes place according to Saytzeff's rule.

## JEE MAIN / JEE ADVANCED

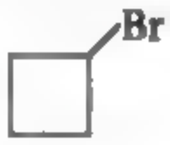
### Only One Option Correct Type

16. 

Give the number of *N* and *M*.

(a) 6, 6 (b) 6, 4 (c) 4, 4 (d) 3, 3

17. 1-Bromo-3-chlorocyclobutane when treated with two equivalents of Na in the presence of ether, which of the following will be formed?

(a)  (b) 

(c)  (d) 

18. From which one of the following, both ethylene and acetylene could be prepared in a single step reaction?

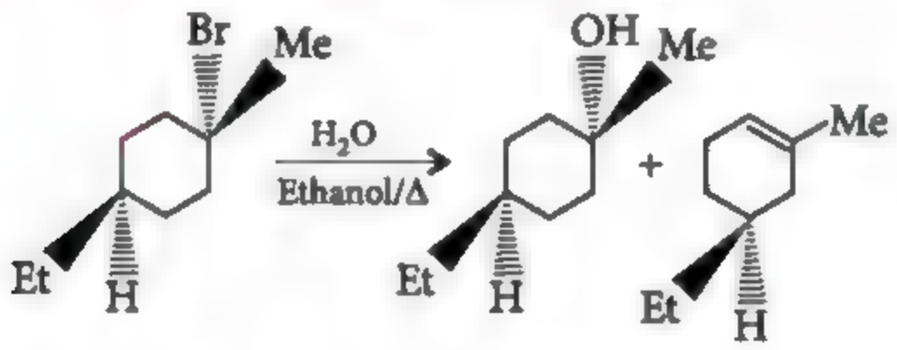
(a) $CH_3CH_2OH$ (b) $BrCH_2CH_2Br$
(c) $CH_3CH_2Br$ (d) $BrCH_2CH_2OH$

19. 2-Bromobutane reacts with $OH^-$ in $H_2O$ to give 2-butanol. The reaction involves

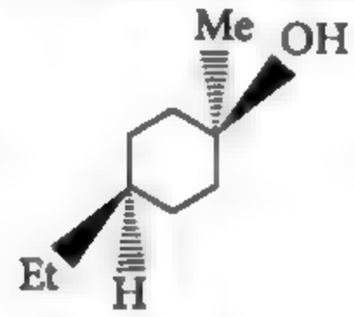
(a) retention of configuration
(b) inversion of configuration
(c) racemization
(d) mutarotation.

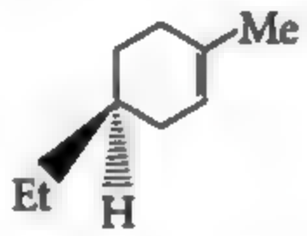
## More than One Options Correct Type

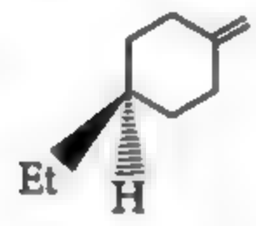
**20.** Consider the following $E1/S_N1$ reaction:

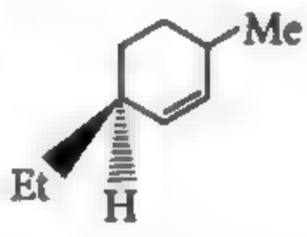



The missing products are

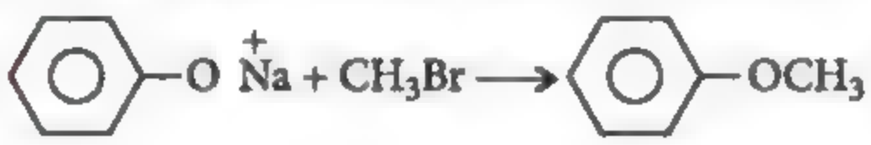
(a) 

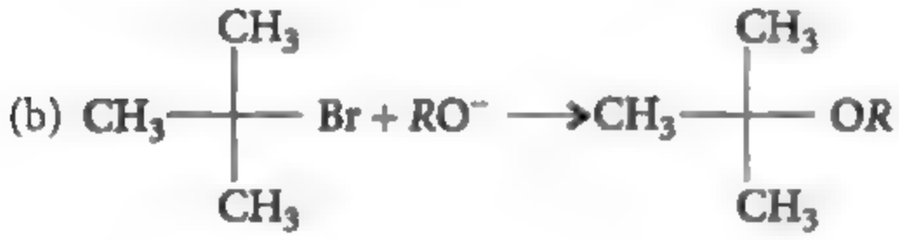

(b) 

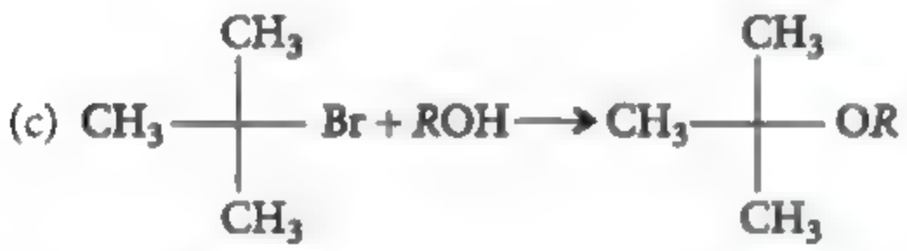

(c) 

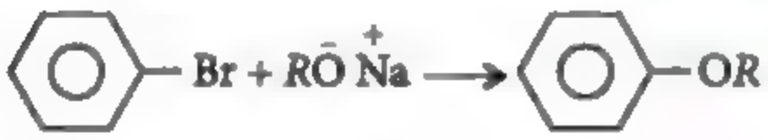

(d) 


**21.** Which of the following reactions are not feasible?

(a) 


(b) 


(c) 


(d) 


**22.** In the reaction given below :




Which of the following statements are not correct?

(a) The reaction proceeds *via* $S_N2$ mechanism hence inversion of configuration takes place.

(b) The reaction proceeds *via* $S_N1$ mechanism hence inversion of configuration takes place.

(c) The reaction proceeds *via* $S_N2$ mechanism hence their is no change in the configuration.

(d) The reaction proceeds *via* $S_N1$ mechanism hence there is no change in the configuration.

**23.** Which of the following reactions take place?

(a) $C_2H_5Br + KNO_2 \longrightarrow C_2H_5-O-N=O + KBr$

(b) $C_2H_5Br + AgNO_2 \longrightarrow C_2H_5-N(=O)-O + AgBr$

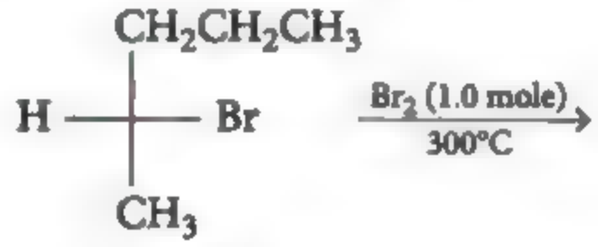
(c) $C_2H_5Br + AgCN \longrightarrow C_2H_5NC + AgBr$

(d) $C_2H_5Br + KCN \longrightarrow C_2H_5NC + KBr$

## Numerical Value Type

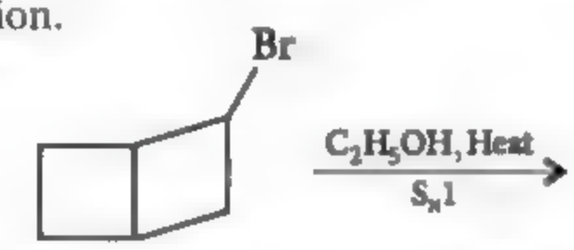
**24.** The total number of alkenes possible by dehydrobromination of 3-bromo-3-cyclopentyl-hexane using alcoholic KOH is

**25.** In the following monobromination reaction, the number of possible chiral products is




(1.0 mole)
(enantiomerically pure)

**26.** Following compound when heated in ethanol, $S_N1$ reaction occurs involving rearrangement of carbocation.




In the major product, how many carbon atoms are present in the single largest ring?

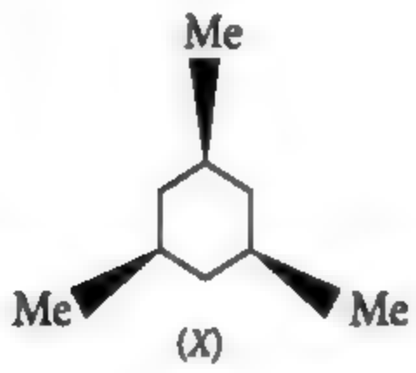
## Comprehension Type

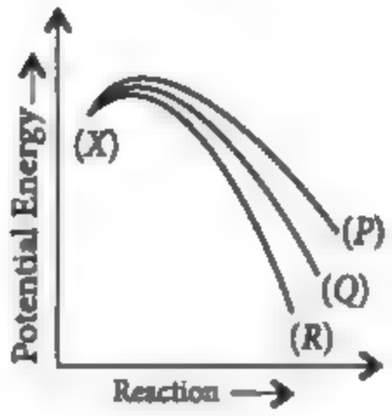
Reactivity ratio for primary, secondary and tertiary radical is 1 : 3.8 : 4.5.

The propagation step of monochlorination of alkane involve formation of free radical intermediate.

$R-H + \dot{Cl} \longrightarrow \dot{R} + H-Cl$

The energy profile for the formation of free radical (*P, Q, R*) is described in the given graph for the compound (*X*).



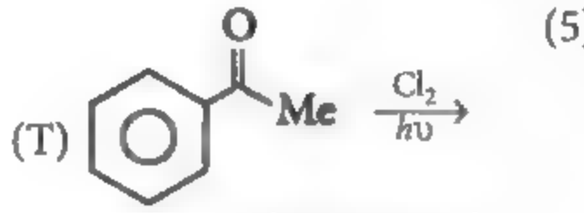




27. For the compound (*X*), which of the following statements is true for the monochlorination of compound (*X*) via intermediate (*Q*).
   (a) Two different products, both optically inactive.
   (b) Two different products, one optically active and other optically inactive.
   (c) Two different products and are diastereomers of each other.
   (d) Only one product is obtained.

28. Which of the following is incorrect for the monochlorination of (*X*)?
   (a) Via intermediate (*P*) only one product is obtained.
   (b) Via intermediate (*R*) two products are obtained which are enantiomers.
   (c) All products obtained are optically inactive.
   (d) The per cent distribution of products formed via intermediate (*P*) is 19.86%.

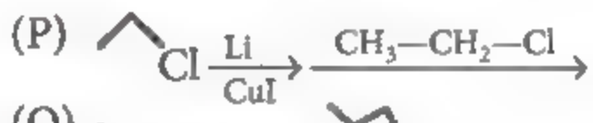
### Matrix Match Type

29. Match the reaction listed in Column I with their characteristics listed in Column II and choose the correct option using the codes given below.

| Column I | Column II |
|---|---|
| (P) $CHCl_3 + HNO_3 \longrightarrow$ An insecticide and tear gas | (1) Gammaxene |
| (Q) Benzene + $Cl_2 \xrightarrow{h\upsilon}$ Product | (2) Hunsdiecker reaction |
| (R)  | (3) Chloropicrin |
| (S) Silver acetate $\xrightarrow[CCl_4]{Br_2}$ $CH_3Br$ | (4) Dichlorodiphenyltrichloroethane |
| (T)  $PhCOCH_2Cl$ Phenacyl chloride | (5) Used as a lachrymator (weeping gas) to disperse the mob by police |

| | P | Q | R | S | T |
|---|---|---|---|---|---|
| (a) | 3 | 1 | 4 | 2 | 5 |
| (b) | 2 | 1 | 4 | 3 | 5 |
| (c) | 5 | 2 | 1 | 3 | 4 |
| (d) | 3 | 1 | 2 | 4 | 5 |

30. Match column I with column II and choose the correct option using the codes given below.

| Column I | Column II |
|---|---|
| (P)  | (1)  |
| (Q)  | (2)  |
| (R)  | (3)  |
| (S)  | (4)  |

| | P | Q | R | S |
|---|---|---|---|---|
| (a) | 2 | 1 | 4 | 3 |
| (b) | 1 | 1, 3 | 2 | 4 |
| (c) | 2, 3 | 1, 2 | 4 | 3 |
| (d) | 2, 4 | 1, 4 | 2 | 4 |

◈◈

*Keys are published in this issue. Search now!* ☺

**SELF CHECK**

| | | | |
|---|---|---|---|
| No. of questions attempted | ..... | **Check your score! If your score is** | |
| No. of questions correct | ..... | > 90% | **EXCELLENT WORK !** You are well prepared to take the challenge of final exam. |
| Marks scored in percentage | ..... | 90-75% | **GOOD WORK !** You can score good in the final exam. |
| | | 74-60% | **SATISFACTORY !** You need to score more next time. |
| | | < 60% | **NOT SATISFACTORY!** Revise thoroughly and strengthen your concepts. |

# CBSE warm-up!

CLASS-XII

**Practice questions for CBSE Exams as per the latest pattern and marking scheme issued by CBSE for the academic session 2020-21.**

**Series 1**

**CHAPTERWISE PRACTICE PAPER :**
**The Solid State | Solutions**

Time Allowed : 3 hours
Maximum Marks : 70

**GENERAL INSTRUCTIONS**

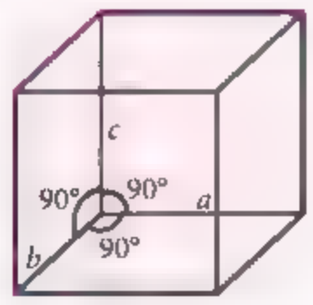
(i) All questions are compulsory.
(ii) Section A: Q.no. 1 to 20 are very short answer questions and carry 1 mark each.
(iii) Section B: Q.no. 21 to 27 are short answer questions and carry 2 marks each.
(iv) Section C: Q.no. 28 to 34 are long answer questions and carry 3 marks each.
(v) Section D: Q.no. 35 to 37 are also long answer questions and carry 5 marks each.
(vi) There is no overall choice. However an internal choice has been provided in two questions of two marks, two questions of three marks and all the three questions of five marks weightage. You have to attempt only one of the choices in such questions.
(vii) Use log tables if necessary, use of calculators is not allowed.

## SECTION-A

**Read the given passage and answer the questions 1 to 5 that follow :**

The geometrical form consisting only of a regular array of points in space is called a lattice or space lattice.
Unit cell is the smallest portion of crystal lattice when repeated in different directions, generates the entire lattice. There are four types of unit cells, simple, face-centred, body-centred and end-centred. On the basis of central geometry of the crystal, crystal systems are classified into seven types of basic unit cells which are called crystallographic systems.

1. Write the name of crystal system of a compound with unit cell dimensions $a = 0.387$, $b = 0.387$ and $c = 0.504$ nm and $\alpha = \beta = 90°$ and $\gamma = 120°$.
2. Which of the crystal system is represented by given unit cell structure?




3. Which arrangement of Cs ions is found in CsCl structure?
4. In which arrangement both the atoms have co-ordination number of eight?
5. How many number of atoms are present in *fcc* unit cell?

**Questions 6 to 10 are one word answers :**

6. Which one of the following is an example of molecular solid : $CO_2$ or $SiO_2$?
7. What type of stoichiometric defect is shown by NaCl?

8. Which type of deviation is shown by mixture of chloroform and acetone?

9. Identify which liquid will have a higher vapour pressure at 90°C if the boiling points of two liquids *A* and *B* are 140°C and 180°C, respectively. **(2020)**

10. What is the coordination number of each type of ions in a rock-salt type crystal structure?

**Questions 11 to 15 are multiple choice questions :**

11. Which of the following statements is not correct?
    (a) The number of carbon atoms in a unit cell of diamond is 8.
    (b) The number of Bravais lattices in which a crystal can be categorized is 14.
    (c) The fraction of the total volume occupied by the atoms in a primitive cell is 0.48.
    (d) Molecular solids are generally volatile.

12. Silicon doped with arsenic is an example of which type of semiconductor?
    (a) *p*-type (b) *n*-type
    (c) *n*, *p*-type (d) Intrinsic

13. A 500 g toothpaste sample has 0.2 g fluoride concentration. What is the concentration of fluoride in terms of ppm level?
    (a) 250 (b) 200
    (c) 400 (d) 1000

14. A supersaturated solution is a metastable state of solution in which solute concentration
    (a) is equal to the solubility of that substance in water
    (b) exceeds its solubility
    (c) less than its solubility
    (d) continuously changes.

15. What happens to freezing point of benzene when naphthalene is added?
    (a) Increases
    (b) Decreases
    (c) Remains unchanged
    (d) First decreases and then increases

**Questions 16 to 20 :**

(a) Both Assertion (A) and Reason (R) are correct statements, and Reason (R) is the correct explanation of the Assertion (A).
(b) Both Assertion (A) and Reason (R) are correct statements, but Reason (R) is not the correct explanation of the Assertion (A).
(c) Assertion (A) is correct, but Reason (R) is incorrect statement.
(d) Assertion (A) is incorrect, but Reason (R) is correct statement.

16. **Assertion :** In a pressure cooker, the water is brought to boil. The cooker is then removed from the stove. Now on removing the lid of pressure cooker, the water starts boiling again.
    **Reason :** The impurities in water bring down its boiling point.

17. **Assertion :** Graphite is an example of tetragonal crystal system.
    **Reason :** For a tetragonal system, $a = b \neq c$, $\alpha = \beta = \gamma = 90°$.

18. **Assertion :** *bcc* and *hcp* has same packing efficiency.
    **Reason :** *bcc* arrangement has 2 atoms per unit cell while *hcp* has 4 atoms per unit cell.

19. **Assertion :** Osmotic pressure is a colligative property.
    **Reason :** Osmotic pressure is directly proportional to molarity. **(2020)**

20. **Assertion :** The number of tetrahedral voids is double the number of octahedral voids.
    **Reason :** The size of the tetrahedral voids is half of that of the octahedral void.

## SECTION - B

21. When water and nitric acid are mixed together, a rise in temperature is observed. What type of azeotropic mixture is obtained?

22. An element with density 11.2 g $cm^{-3}$ forms a *fcc* lattice with edge length of $4 \times 10^{-8}$ cm. Calculate the atomic mass of the element.
    (Given : $N_A = 6.022 \times 10^{23}$ $mol^{-1}$)
    **(2/5, 2018 C, Delhi 2014)**

23. The freezing point of a solution having 50 $cm^3$ of ethylene glycol in 50 g water is found to be – 34 °C. Calculate the density of ethylene glycol, assuming ideal behaviour.
    ($K_f$ for water = 1.86 K kg $mol^{-1}$)

    **OR**

    Determine the osmotic pressure of a solution prepared by dissolving 25 mg of $K_2SO_4$ in 2 L of water at 25 °C, assuming that it is completely dissociated.

24. Examine the given defective crystal :

| | | | | |
|---|---|---|---|---|
| $A^+$ | $B^-$ | $A^+$ | $B^-$ | $A^+$ |
| $B^-$ | ○ | $B^-$ | $A^+$ | $B^-$ |
| $A^+$ | $B^-$ | $A^+$ | ○ | $A^+$ |
| $B^-$ | $A^+$ | $B^-$ | $A^+$ | $B^-$ |

    Answer the following questions :
    (i) What type of stoichiometric defect is shown by the crystal?

CONCEPT MAP

# HALOALKANES AND HALOARENES

## 1 Classification

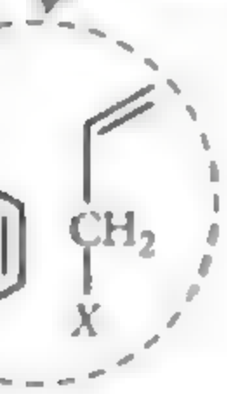
On the basis of number halgoen atoms

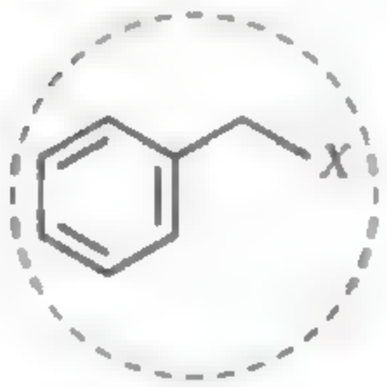
- Monohalogen, e.g., $R—CH_2X$
- Dihalogen, e.g., $X—CH_2CH_2—X$
- Trihalogen, e.g., $CHX_3$

Haloalkanes $R—X$

Compounds containing $sp^3$ C—X bond

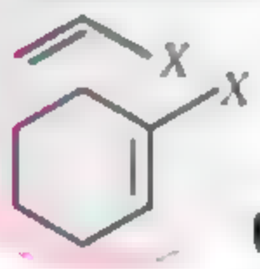
- Allylic halide
- Benzylic halide



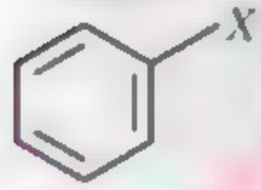


Compounds containing $sp^2$ C—X bond

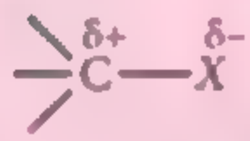
- Vinylic halide



- Aryl halide



## 2 Nature of C—X Bond



$C—F, C—Cl, C—Br, C—I$ ⟶

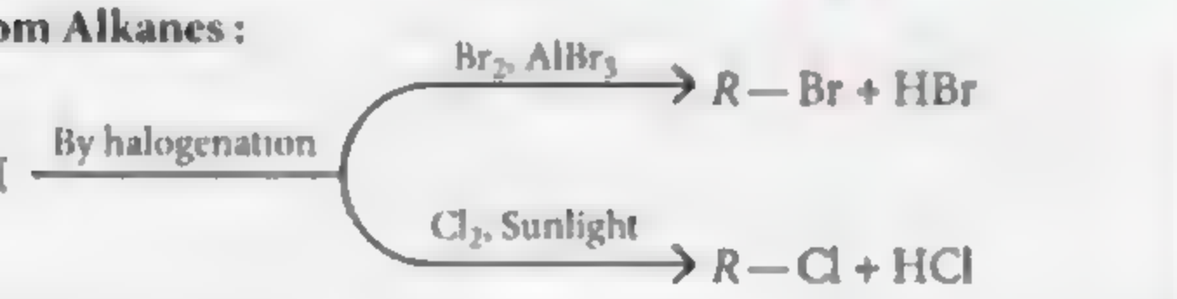
Size of halogen atoms increases

$C—X$ bond length increases

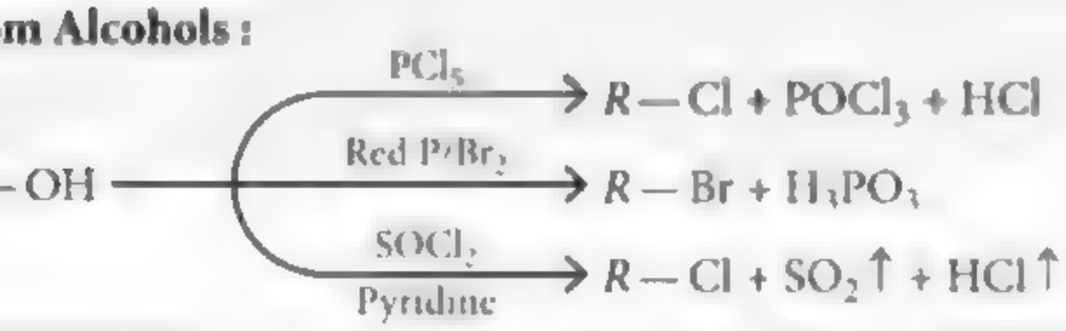
Bond enthalpy decreases

## 3 Methods of Preparation

### From Alkanes :




### From Alcohols :



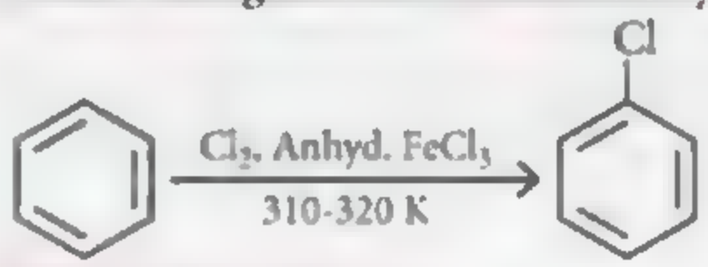

**kelstein Reaction :** $R—X + NaI \xrightarrow{\text{Dry acetone}} R—I + NaX$

**rts Reaction :** $RBr + AgF \longrightarrow R—F + AgBr$

**nsdiecker Reaction :**

$OOAg + Br_2 \xrightarrow{CCl_4/\text{Reflux}} R—Br + CO_2 + AgBr$

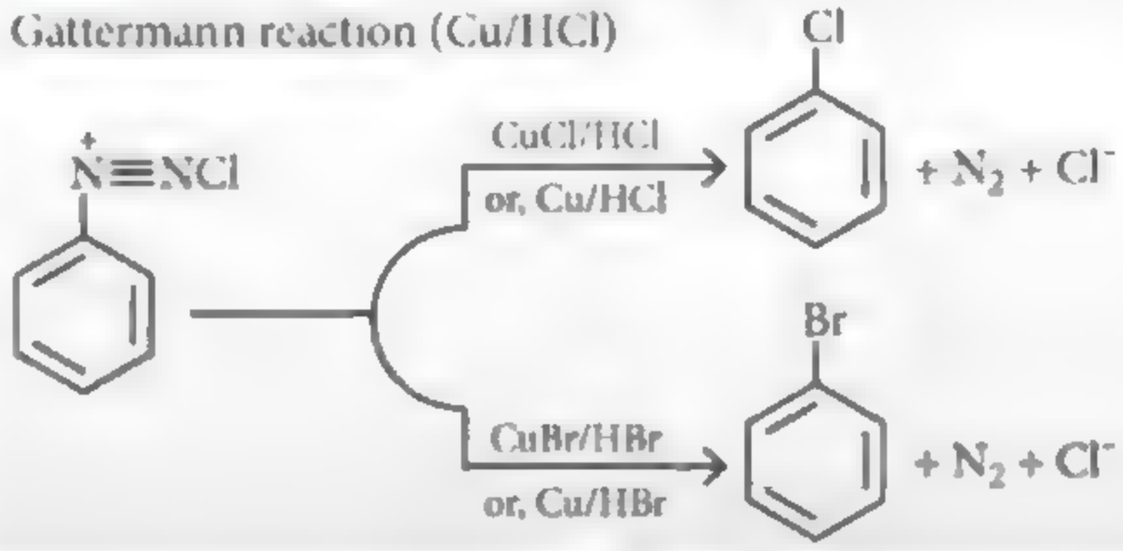
- **Direct halogenation of aromatic hydrocarbons :**




- **From diazonium salts :**

Sandmeyer's reaction (CuCl/HCl) and

Gattermann reaction (Cu/HCl)

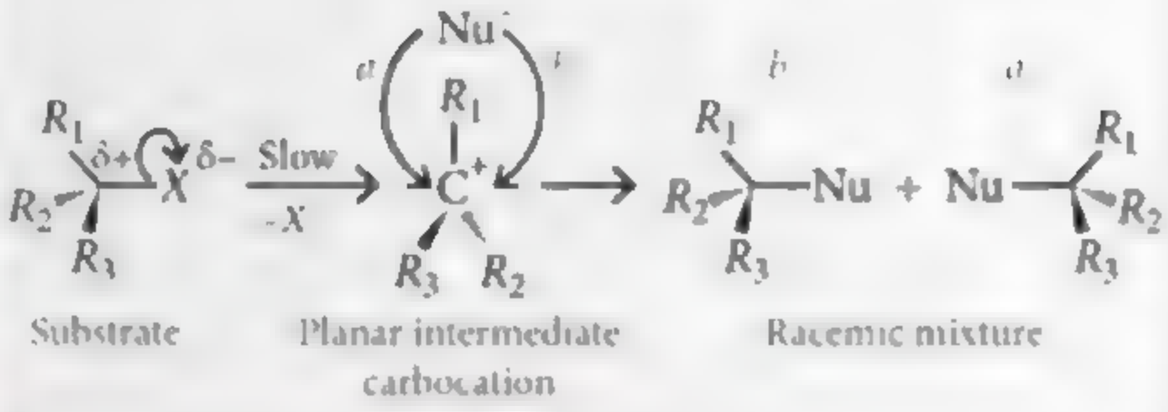



## 4 Chemical Properties

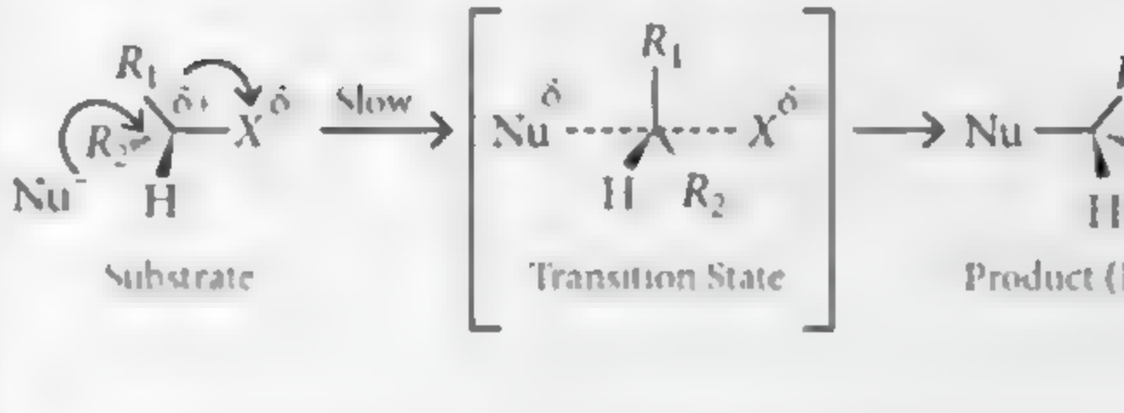
## 5 Stereochemistry

## Nucleophilic Substitution Reactions

### $S_N1$ (Racemisation)



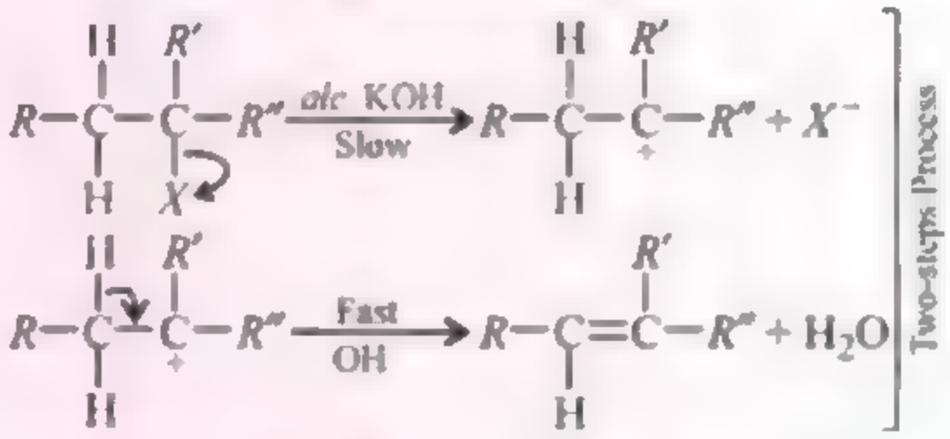

### $S_N2$ (Inversion of Configuration)




## Elimination Reactions

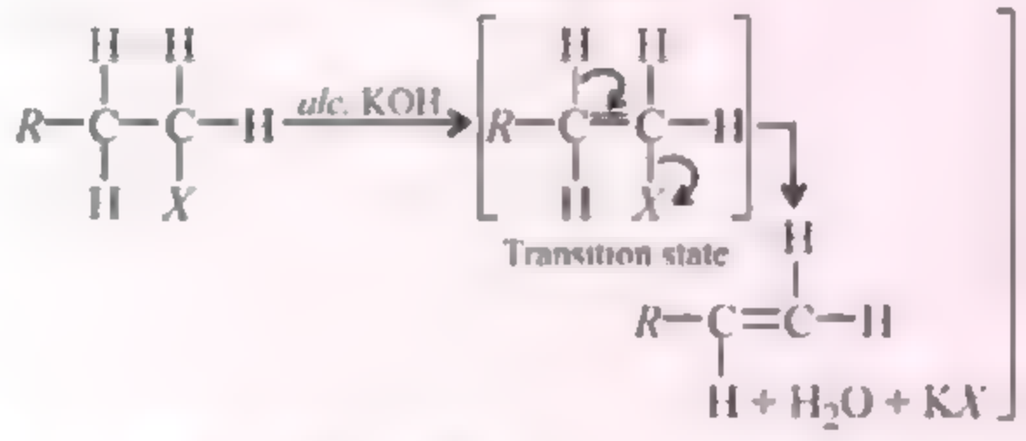
Alkyl halides undergo β-elimination reaction in the presence of potassium hydroxide in ethanol (high temperature) to yield a

### E1 mechanism




Rate = $k$ [Alkyl halide]

### E2 mechanism

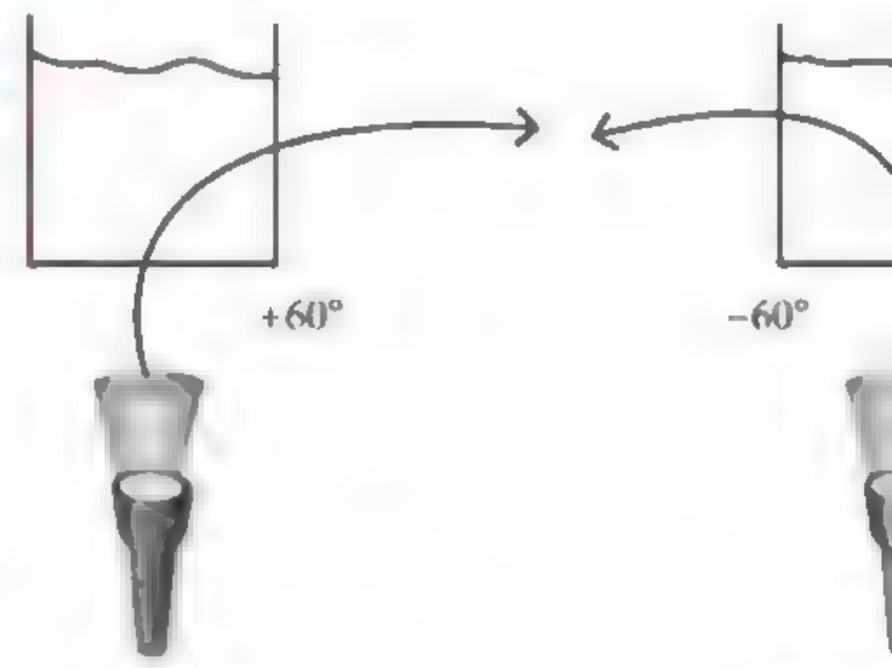



Rate = $k$ [Alkyl halide] [base]

## Optical Activity

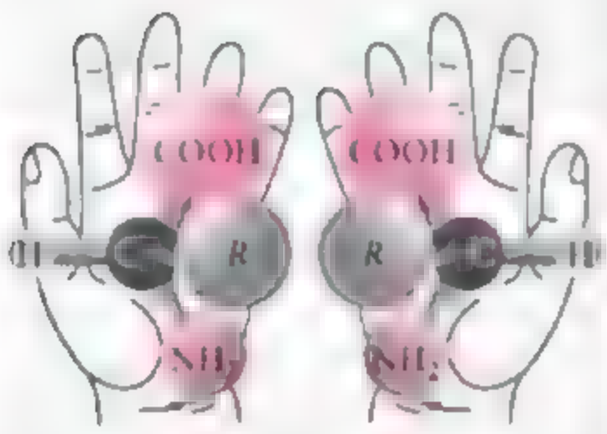
Plane polarised light produced by passing ordinary light through nicol prism is rotated when it is passed through the solutions of certain compounds. Such compounds are called optically active compounds.

**Chirality :** The objects which are non-superimposable on their mirror images are said to be chiral.

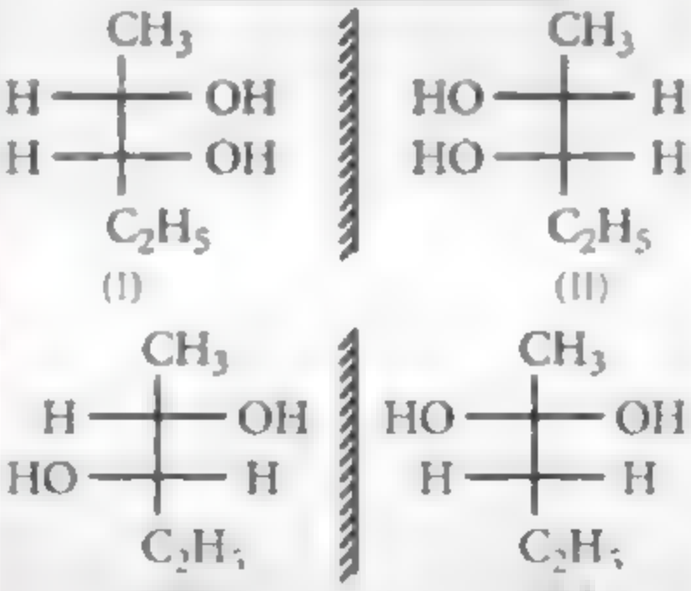



The direction and magnitude of rotation must be determined experimentally. There is no correlation between (*R*) and (*S*) configuration and the direction of rotation.

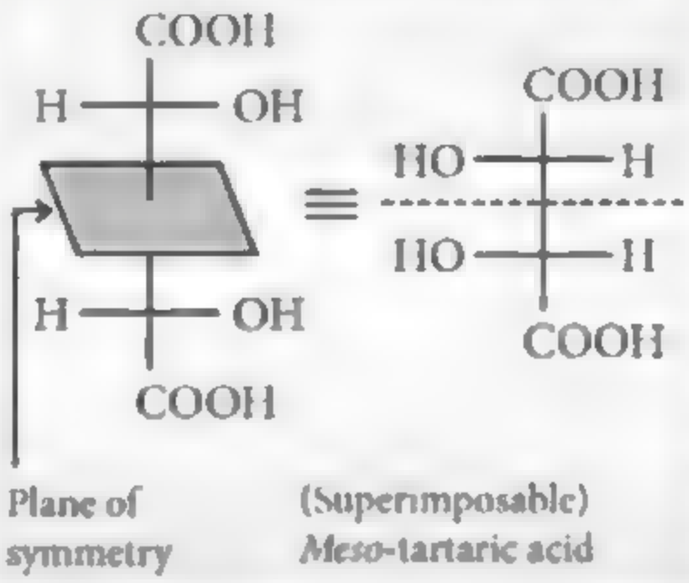
**Enantiomers :** Compounds having non-superimposable mirror images with same physical and chemical properties.




**Diastereomers :** Compounds which are not mirror images (I and III, II and IV) of each other with different physical properties but same chemical properties.




**Meso compounds :** These are optically inactive compounds as there exists a plane of symmetry which divides the molecule into two identical halves.




**Racemic mix**

A mixture of amounts of enantiomers is *racemic mixt* *racemic modifi*

A racemic mixture is optically inactive the rotation caused molecules of one enant exactly cancelled by eq opposite rotation cau the same number of m of the other enantiom represented by prefi or (±) before the na example, (±) butan-2-

(ii) How is the density of the crystal affected by this defect?

25. An aqueous solution of 2% non-volatile solute exerts a pressure of 1.004 bar at the normal boiling point of the solvent. What is the molecular mass of the solute?

OR

The boiling point elevation of 0.30 g acetic acid in 100 g benzene is 0.0633 K. Calculate the molar mass of acetic acid. What conclusion can you draw about the molecular state of the solute in the solution?
(Given : $K_b$ for benzene = 2.53 K kg $mol^{-1}$)

26. Answer the following :
(i) A compound formed by elements *A* and *B* crystallises in the cubic structure where *A* atoms are at the corners of the cube and *B* atoms are at the centre of the cube. What is the formula of the compound?
(ii) In chromium (III) chloride, $CrCl_3$, the chloride ions have *ccp* (cubic close packing) arrangement and Cr(III) ions are present in octahedral holes. What fraction of the octahedral holes is occupied? What fraction of the total number of holes is occupied?

27. Answer the following:
(i) Explain why melting point of a substance is an index of its purity.
(ii) Ether and spirit give a cooling sensation on rubbing on the skin. Why?

## SECTION-C

28. Aluminium crystallises in a cubic close packed structure with radius 125 pm. Then,
(i) what is the edge length of the unit cell?
(ii) how many unit cells are there in 1 $cm^3$ of aluminium?

OR

(i) *X*-ray diffraction studies shows that the edge length of unit cell of NaCl is 0.56 nm. The density of NaCl was found to be 2.16 g/cc. What type of defect is present in the solid? Calculate the percentage of $Na^+$ and $Cl^-$ ions missing.
(ii) What happens when a ferromagnetic or antiferromagnetic or ferrimagnetic solid is heated?

29. Amongst the following compounds, identify which are insoluble, partially soluble and highly soluble in water.
(i) Phenol (ii) Toluene
(iii) Formic acid (iv) Ethylene glycol
(v) Chloroform (vi) Pentanol

30. Answer the following:
(i) Give one similarity and one difference between metallic and ionic crystals.
(ii) Why are ionic solids hard and brittle?

31. An element crystallises in *fcc* lattice having edge length 400 pm. Calculate the maximum diameter of atom which can be placed in interstitial site without distorting the structure.

OR

How many millilitres of 0.1 M HCl are required to react completely with 1 g mixture of $Na_2CO_3$ and $NaHCO_3$ containing equimolar amounts of both?

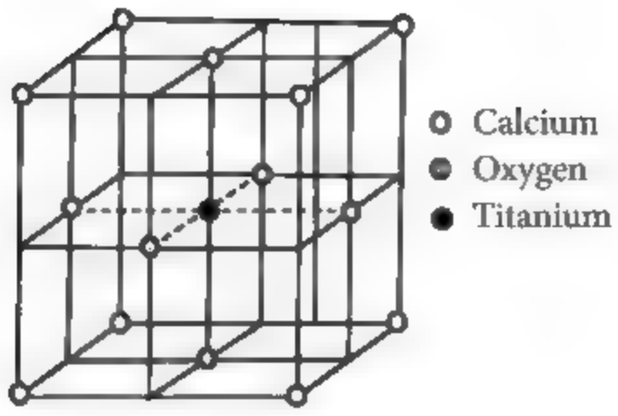
32. A solution contains 5.85 g NaCl (Molar mass = 58.5 g $mol^{-1}$) per litre of solution. It has an osmotic pressure of 4.75 atm at 27°C. Calculate the degree of dissociation of NaCl in this solution.
(Given : $R$ = 0.082 L atm $K^{-1}$ $mol^{-1}$) **(3/5, 2020)**

33. Vapour pressures of chloroform ($CHCl_3$, 119.5 g $mol^{-1}$) and dichloromethane ($CH_2Cl_2$, 85 g $mol^{-1}$) at 298 K are 200 mmHg and 415 mmHg respectively. Calculate
(a) vapour pressure of the solution prepared by mixing 25.5 g of $CHCl_3$ and 40 g of $CH_2Cl_2$ at 298 K and
(b) mole fraction of each component in vapour phase.

34. In terms of band theory, what is the difference between
(i) a conductor and an insulator
(ii) a conductor and a semiconductor?

## SECTION-D

35. Answer the following :
(i) Non-stoichiometric cuprous oxide, $Cu_2O$ can be prepared in the laboratory. In this oxide, copper to oxygen ratio is slightly less than 2 : 1. Can you account for the fact that this substance is a *p*-type semiconductor?
(ii) Perovskite, a mineral containing calcium, oxygen and titanium crystallises in the given cubic unit cell.




What is the formula of perovskite and what is the oxidation number of titanium in perovskite?

OR

Answer the following :

(i) Calculate the packing efficiency of a metal for a simple cubic lattice.

(ii) Silver crystallises in face centred cubic unit cell. Each side of this unit cell has a length of 400 pm. Calculate the radius of the silver atom. (Assume that the atom just touch each other on the diagonal across the face of the unit cell, that is each face atom is touching the four corner atoms).

**36.** Answer the following :

(i) What happens when red blood corpuscles (RBC) are placed in

(a) 0.5% NaCl solution

(b) 1% NaCl solution?

(ii) A binary solution of two volatile liquids *A* and *B* in which mole fraction of *A* is $x_A$, is reported to have total vapour pressure equal to *P* mbar. *P* is defined by the relation,

$P = 255 - 120\, x_A$

What are the values of $p^\circ_A$ and $p^\circ_B$?

OR

1.22 g of benzoic acid is dissolved in

(a) 100 g of acetone ($K_b$ for acetone = 1.7 K kg $mol^{-1}$) and

(b) 100 g of benzene ($K_b$ = 2.6 K kg $mol^{-1}$). The elevations in boiling points $\Delta T_b$ is 0.17 °C and 0.13 °C respectively.

(i) What are molar masses of benzoic acids in two solvents?

(ii) What do you deduce out of it in terms of structure of benzoic acid?

**37.** Answer the following :

(i) Analysis shows that nickel oxide has the formula $Ni_{0.98}O_{1.00}$. What fractions of nickel exist as $Ni^{2+}$ and $Ni^{3+}$ ions?

(ii) Why does ZnO appear golden yellow at high temperature?

(iii) $Fe_3O_4$ is ferrimagnetic at room temperature and becomes paramagnetic at 850 K.

OR

Answer the following :

(i) Given reason :

(a) Why is Frenkel defect found in AgCl?

(b) What is the difference between phosphorus doped and gallium doped silicon semiconductors?

(ii) Why are solids incompressible ?

(iii) Give significance of a lattice point.

## SOLUTIONS

1. Hexagonal system
2. Cubic system
3. *bcc* (Body centred cubic)
4. Body centred cubic (*bcc*)
5. 4
6. $CO_2$
7. Schottky defect
8. Negative
9. Liquid *A*
10. 6

**11. (c) :** Packing fraction for a cubic unit cell is given by $f = \dfrac{Z \times \frac{4}{3}\pi r^3}{a^3}$

where, *a* = edge length, *r* = radius of cation and anion. Efficiency of packing in simple cubic or primitive cell = $\pi/6 = 0.52$ *i.e.*, 52% of unit cell is occupied by atoms and 48% is empty.

**12. (b) :** Silicon ($14^{th}$ group) doped with arsenic ($15^{th}$ group) forms *n*-type semiconductor.

**13. (c) :** Concentration (ppm) = $\dfrac{0.2}{500} \times 10^6 = 400$

**14. (b) :** When a saturated solution prepared at a higher temperature is cooled, it gives a solution which contains usually more of solute than required for the saturated solution at that temperature. Such a solution is referred to as a supersaturated solution. It is usually unstable and changes to saturated solution when excess of solute comes out in solid state.

**15. (b)**

**16. (c) :** In pressure cooker, water boils above 100°C. When the lid of cooker is opened, pressure is lowered so that boiling point decreases and water boils again.

**17. (d) :** Graphite has a two dimensional sheet structure. Each C-atom is in $sp^2$ hybridised state and is linked to three other carbon atoms in a hexagonal planar structure.
For a tetragonal system, $a = b \neq c$, $\alpha = \beta = \gamma = 90°$. For a hexagonal system, $a = b \neq c$, $\alpha = \beta = 90°$, $\gamma = 120°$.

**18. (d) :** *bcc* has 68% and *hcp* has 74% packing efficiency.
*bcc* arrangement has 2 atoms per unit cell, while *hcp* has 4 atoms per unit cell. Also, *bcc* and *hcp* have different arrangements of particles.

**19. (a) :** Colligative properties of ideal solutions depend only on the number of particles of solute dissolved in a definite amount of the solvent and do not depend on the nature of solute.

**20. (c) :** The size of tetrahedral voids is smaller but not half of that of the octahedral voids.

**21.** Since a rise in temperature is observed when water and nitric acid are mixed together, the mixture is showing negative deviation from Raoult's law. Maximum boiling azeotropes are obtained by liquid mixtures showing negative deviation.

**22.** Given : $d = 11.2\ \text{g cm}^{-3}$, $Z = 4$, $a = 4 \times 10^{-8}$ cm,
$M = ?$, $N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

$$M = \frac{d \times a^3 \times N_A}{Z} = \frac{11.2 \times (4 \times 10^{-8})^3 \times 6.022 \times 10^{23}}{4}$$

$= 108\ \text{g mol}^{-1}$

**23.** Amount of ethylene glycol,

$$w_2 = \frac{M_2 \times \Delta T_f \times w_1}{K_f \times 1000} = \frac{62 \times 34 \times 50}{1.86 \times 1000} = 56.67\ \text{g}$$

(As, molar mass of ethylene glycol is 62 g mol$^{-1}$)

$$\text{Density, } d = \frac{\text{Mass}}{\text{Volume}} = \frac{56.67}{50} = 1.13\ \text{g cm}^{-3}$$

**OR**

$K_2SO_4$ dissolved = 25 mg = 0.025 g
Volume of solution = 2 L
$T = 25\ °\text{C} = 25 + 273\ \text{K} = 298\ \text{K}$
Molar mass of $K_2SO_4 = 2 \times 39 + 32 + 4 \times 16$
$= 174\ \text{g mol}^{-1}$
$K_2SO_4$ dissociates completely as
$K_2SO_4 \rightarrow 2K^+ + SO_4^{2-}$
*i.e.*, ions produced = 3 ($\therefore\ i = 3$)

$$\therefore\ \pi = iCRT = i\frac{n}{V}RT = i \times \frac{w}{M} \times \frac{1}{V}RT$$

$$\pi = 3 \times \frac{0.025}{174} \times \frac{1}{2} \times 0.0821 \times 298 = 5.27 \times 10^{-3}\ \text{atm}$$

**24. (i)** Schottky defect
**(ii)** Density of the crystal decreases.

**25.** Vapour pressure of pure water at its boiling point ($p^o$) = 1 atm = 1.013 bar
Vapour pressure of solution ($p_s$) = 1.004 bar
Let mass of solution be 100 g, then,
Mass of solute ($w_2$) = 2 g
Mass of solvent ($w_1$) = 100 – 2 = 98 g
By Raoult's law for dilute solution,

$$\frac{p^o - p_s}{p_s} = \frac{n_2}{n_1} = \frac{w_2 / M_2}{w_1 / m_1} = \frac{w_2}{m_2} \times \frac{M_1}{w_1}$$

$$\frac{1.013 - 1.004}{1.004} = \frac{2}{M_2} \times \frac{18}{98}$$

$$M_2 = \frac{2 \times 18}{98 \times 8.96 \times 10^{-3}} = 40.998 \simeq 41\ \text{g mol}^{-1}$$

**OR**

$$M_2 = \frac{K_b \times w_2 \times 1000}{\Delta T_b \times w_1} = \frac{2.53 \times 0.30 \times 1000}{0.0633 \times 100}$$

$\simeq 120\ \text{g mol}^{-1}$
Molar mass of $CH_3COOH$ = 60 g/mol

$$i = \frac{M_{2(\text{calculated})}}{M_{2(\text{observed})}} = \frac{60}{120} = \frac{1}{2} = 0.5$$

As $i = 0.5$, therefore the solute (acetic acid) is dimerised in benzene.

**26. (i)** An atom at the corner of a cube is shared by 8 unit cells and hence, contributes only $1/8^{\text{th}}$ to a particular unit cell.

$\therefore$ No. of *A* atoms in the unit cell $= 8 \times \frac{1}{8} = 1$

An atom at the centre of cube belongs only to one unit cell.
$\therefore$ Number of *B* atoms in the unit cell $= 1 \times 1 = 1$
Therefore, formula of the compound is *AB*.
**(ii)** In *ccp* arrangement, each chloride ion would have one octahedral void and two tetrahedral voids associated with it.
Number of octahedral voids with 3 chloride ions = 3
Number of tetrahedral voids with 3 chloride ions
$= 3 \times 2 = 6$
Total number of voids with 3 chloride ions = 9
Number of octahedral voids occupied by Cr (III) = 1
Fraction of octahedral voids occupied = 1/3
Fraction of total number of voids occupied = 1/9

**27. (i)** The presence of impurity reduces the melting point of a substance, *i.e.*, greater the impurity, lesser is the melting point. Hence, melting point is taken as an index of purity of a substance.

(ii) Ether and spirit are highly volatile. When rubbed on skin, they absorb heat energy from the body and evaporate. Due to loss of heat energy, cooling sensation is observed on the skin.

**28.** (i) For cubic closed packed structure,

Edge length, $a = 2\sqrt{2}\,r = 2\sqrt{2} \times 125$ pm

$= 250\sqrt{2}$ pm $= 353.55$ pm $= 353.55 \times 10^{-12}$ m

$= 353.55 \times 10^{-10}$ cm

(ii) Volume of 1 unit cell $= (353.55 \times 10^{-10})^3$ cm$^3$

$= 4.4193 \times 10^{-23}$ cm$^3$

$4.4193 \times 10^{-23}$ cm$^3$ = 1 unit cell

$$\therefore \quad 1 \text{ cm}^3 = \frac{1}{4.4193 \times 10^{-23}} = 2.263 \times 10^{22} \text{ unit cells}$$

**OR**

(i) Density of the NaCl

$$\rho = \frac{Z \times M}{a^3 \times N_A} = \frac{4 \times 58.5}{(0.56 \times 10^{-7})^3 \times 6.023 \times 10^{23}}$$

$= 2.212$ g/cc

Observed density is less than theoretical density, hence, the solid has Schottky defect.

$$Z = \frac{a^3 \times \rho \times N_A}{M}$$

$$Z = \frac{(0.56 \times 10^{-7})^3 \times 2.16 \times 6.023 \times 10^{23}}{58.5} = 3.905$$

Number of missing formula units $= 4 - 3.905 = 0.095$

Percentage of missing formula units

$$= \frac{0.095}{4} \times 100 = 2.375\%$$

$\therefore$ % of $Na^+$ ions missing = 2.375 %

% of $Cl^-$ ions missing = 2.375 %

(ii) Ferromagnetic, anti-ferromagnetic and ferri magnetic solids become paramagnetic on heating above a certain temperature. It is due to randomisation of spins of unpaired electrons.

**29.** (i) Partially soluble because phenol has polar —OH group and non-polar — $C_6H_5$ group.

(ii) Insoluble because toluene is non-polar while water is polar.

(iii) Highly soluble because formic acid can form hydrogen bonds with water.

(iv) Highly soluble because ethylene glycol can form hydrogen bonds with water.

(v) Insoluble because chloroform is an organic liquid.

(vi) Partially soluble because —OH group is polar but the large hydrocarbon part (— $C_5H_{11}$) is non-polar.

**30.** (i) The difference between metallic crystal and ionic crystal is that the constituent particles in metallic crystals are positively charged metal ions immersed in a sea of mobile electrons while in ionic solids, the constituent particles are cations and anions.

The similarity between metallic crystal and ionic crystal is that both metallic as well as ionic solids have high melting points.

(ii) Ionic solids are hard because in ionic solids, ions are held together by strong electrostatic forces of attractions and thus, the ions are closely packed in the lattice. These are brittle as, when sufficient force is applied on an ionic crystal, the ions with similar charges come close due to displacement and repel each other and then, the crystal shatters.

**31.** In a cubic crystal system, there are two types of voids known as octahedral and tetrahedral voids. If $r_1$ is the radius of void and $r_2$ is the radius of atom in close packing then,

$$\left(\frac{r_1}{r_2}\right)_{\text{octahedral}} = 0.414 \text{ and } \left(\frac{r_1}{r_2}\right)_{\text{tetrahedral}} = 0.225$$

The above radius ratio values indicate that octahedral void has larger radius hence, for maximum diameter of atom to be present in interstital space,

$r_1 = 0.414\, r_2$

Also, in *fcc*, $r_2 = \frac{a}{2\sqrt{2}}$

Diameter required $= 2r_1 = 2 \times r_2 \times 0.414$

$$= \frac{a}{2\sqrt{2}} \times 2 \times 0.414 = \frac{400 \times 0.414}{\sqrt{2}} \approx 117 \text{ pm}$$

**OR**

Let mass of $Na_2CO_3$ and $NaHCO_3$ in the mixture be $x$ g and $(1 - x)$ g respectively.

Molar mass of $Na_2CO_3$ = 106 g/mol

Molar mass of $NaHCO_3$ = 84 g/mol

Number of moles of $Na_2CO_3$ = Number of moles of $NaHCO_3$

$$\frac{x}{106} = \frac{(1-x)}{84}$$

On solving, $x \approx 0.5579$

Thus, number of moles of $Na_2CO_3$

= Number of moles of $NaHCO_3 = 5.263 \times 10^{-3}$

During the process of neutralisation, following reactions take place :

$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2\uparrow$

$NaHCO_3 + HCl \longrightarrow NaCl + H_2O + CO_2\uparrow$

Number of moles of HCl required

= 2 × number of moles of $Na_2CO_3$

+ number of moles of $NaHCO_3$

$= 2 \times 5.263 \times 10^{-3} + 5.263 \times 10^{-3} \approx 0.0158$

Molarity may be given as,

$$M = \frac{n_B \times 1000}{V} \qquad (n_B = \text{Number of moles of solute})$$

$$V = \frac{n_B \times 1000}{M} = \frac{0.0158 \times 1000}{0.1} = 158 \text{ mL}$$

**32.** $\pi = iCRT = i \cdot \frac{n}{V} RT = i \times \frac{w}{M} \times \frac{1}{V} RT$

or $4.75 = i \times \frac{5.85}{58.5} \times \frac{1}{1} \times 0.082 \times 300$

or $i = 1.93$

$$NaCl \longrightarrow Na^+ + Cl^-$$

| | | | |
|---|---|---|---|
| Initial moles | $C$ | 0 | 0 |
| Moles at eqm. | $C - \alpha$ | $C\alpha$ | $C\alpha$ |

Total no. of moles $= C(1 + \alpha)$

$$i = \frac{C(1+\alpha)}{C}$$

or $i = 1 + \alpha$ or $1 + \alpha = 1.93$ or $\alpha = 0.93$ or 93%

**33. (a)** $P_{total} = p_1^\circ x_1 + p_2^\circ x_2 = p^\circ_{CHCl_3} x_{CHCl_3} + p^\circ_{CH_2Cl_2} x_{CH_2Cl_2}$

| Component | Amount | No. of moles | Mole fraction |
|---|---|---|---|
| $CHCl_3$ | 25.5 g | $\frac{25.5}{119.5} = 0.2134$ | $x_{CHCl_3} = \frac{n_{CHCl_3}}{n_{Total}} = 0.312$ |
| $CH_2Cl_2$ | 40 g | $\frac{40}{85} = 0.4706$ | $x_{CH_2Cl_2} = 1 - x_{CHCl_3} = 0.688$ |

Vapour pressure due to $CHCl_3$,

$p_{CHCl_3} = p^\circ_{CHCl_3} x_{CHCl_3} = 200 \times 0.312 = 62.4$ mmHg

Vapour pressure due to $CH_2Cl_2$,

$p_{CH_2Cl_2} = 415 \times 0.688 = 285.52$ mmHg

Total vapour pressure = 62.4 + 285.52 = 347.92 mmHg

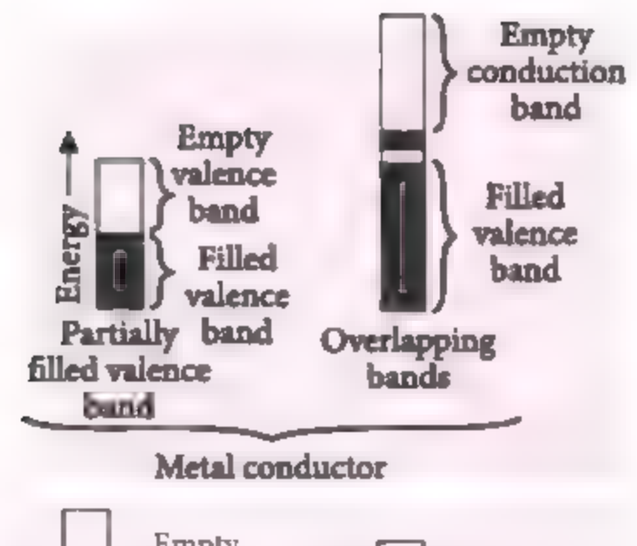
**(b)** Thus, mole fraction of $CHCl_3$ in vapour phase,

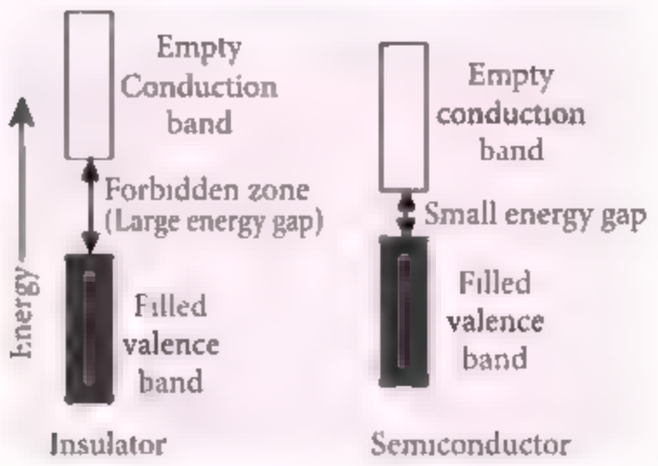
$$y_{CHCl_3} = \frac{p_{CHCl_3}}{P_{Total}} = \frac{62.4}{347.92} = 0.179$$

Mole fraction of $CH_2Cl_2$ in vapour phase,

$y_{CH_2Cl_2} = 1 - 0.1794 = 0.8205$

**34. (i)** In metals, conductivity strongly depends upon the number of valence electrons available in an atom. The atomic orbitals of metal atoms form molecular orbitals which are so close in energy to each other. This set of molecular orbital is called a band. If this band is partially filled or it overlaps with the higher energy unoccupied conduction band, then electrons can flow easily under an applied electric field and the metal behaves as a conductor.




If the gap between the filled valence band and the unoccupied conduction band is large, electrons cannot jump into it and such a substance behaves as an insulator.

**(ii)** If the gap between the valence band and conduction band is small, some electrons may jump from valence band to the conduction band. Such a substance shows some conductivity and behaves as a semiconductor. Electrical conductivity of semiconductors increases with increase in temperature, since more electrons can jump to the conduction band. Silicon and germanium show this type of behaviour and are called intrinsic semiconductors. Conductors have no forbidden band.

**35. (i)** In $Cu_2O$, the ratio is less than 2 : 1, which shows that some cuprous, $Cu^+$ ions have been replaced by cupric ($Cu^{2+}$) ions. Thus, to maintain electrical neutrality, every two $Cu^+$ ions will be replaced by one $Cu^{2+}$ ion, therefore, creating a hole. As conduction is due to the presence of these positive holes, hence, it is a *p*-type semiconductor.

**(ii)** Calcium is present at the corners,

Hence, number of calcium atoms = $1/8 \times 8 = 1$

Oxygen is present at face-centres,

hence, number of oxygen atoms = $1/2 \times 6 = 3$

Titanium is present at the body centre hence, number of titanium atom = 1

Thus, perovskite has formula $CaTiO_3$.

Let oxidation number of Ti be $x$.

$2 + x - 6 = 0 \Rightarrow x = +4$

Thus, oxidation number of Ti in $CaTiO_3 = +4$

OR

(i) Packing efficiency $= \dfrac{Z \times \frac{4}{3}\pi r^3}{a^3} \times 100$

For a simple cubic lattice, $a = 2r$ and $Z = 1$

$\therefore$ Packing efficiency $= \dfrac{1 \times \frac{4}{3}\pi r^3}{(2r)^3} \times 100 = 52.4\%$

(ii) For *fcc*, $r = \dfrac{a}{2\sqrt{2}}$, $a = 400$ pm,

$\therefore \quad r = \dfrac{400}{2\sqrt{2}} = \dfrac{400}{2\sqrt{2}} \times \dfrac{\sqrt{2}}{\sqrt{2}} = \dfrac{400\sqrt{2}}{4} = 100\sqrt{2}$

$\Rightarrow r = 100 \times 1.414 = 141.4$ pm

**36. (i) (a)** The cells will swell or even burst due to haemolysis because 0.5% NaCl solution is hypotonic w.r.t. salt concentration in blood plasma.

**(b)** The cells will shrink due to plasmolysis, because 1% solution of NaCl is hypertonic w.r.t. salt concentration in blood plasma.

**(ii)** $P_{Total} = 255 - 120\, x_A$

For pure $A$, $x_A \rightarrow 1$, $P_{Total} \rightarrow p_A^\circ$

Substituting in the given equation, we get

$p_A^\circ = 255 - 120 \times 1 = 135$ mbar

For pure, $B$, $x_B \rightarrow 1$; $x_A = \rightarrow 0$ and $P_{Total} \rightarrow p_B^\circ$

Substituting in given equation, we get

$p_B^\circ = 255 - 120 \times 0 = 255$ mbar

OR

(i) $\Delta T_b = K_b m = K_b \dfrac{w_B}{M_B \times w_A \text{ (in kg)}}$

Let molar mass of benzoic acid be $M_B$ and $M_B'$ in acetone and benzene respectively. In acetone :

$0.17 = \dfrac{1.7 \times 1.22 \times 1000}{M_B \times 100} \Rightarrow M_B = 122 \text{ g mol}^{-1}$

In benzene : $0.13 = \dfrac{2.6 \times 1.22 \times 1000}{M_B' \times 100}$

$M_B' = \dfrac{2.6 \times 1.22 \times 1000}{0.13 \times 100} = 244 \text{ g mol}^{-1}$

(ii) Calculated molar mass of benzoic acid

$(C_6H_5COOH) = 72 + 5 + 12 + 32 + 1 = 122 \text{ g mol}^{-1}$

van't Hoff factor, $i = \dfrac{\text{Calculated molar mass}}{\text{Observed molar mass}}$

In acetone, $i = 122/122 = 1$

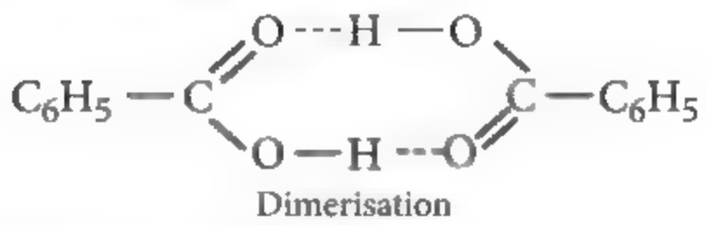
Thus, benzoic acid remains as such in acetone.

**Structure in acetone :** $C_6H_5-C(=O)-O-H$

In benzene, $i = 122/244 = 0.5$

Thus, benzoic acid dimerises in benzene.

**Structure in benzene :**




Dimerisation

**37. (i)** $Ni_{0.98}O_{1.0}$

Let number of $Ni^{2+}$ be $x$.

Then, number of $Ni^{3+}$ will be $0.98 - x$.

Total charge on the compound must be zero, thus,

$2x + 3(0.98 - x) - 2 = 0$; $2x + 2.94 - 3x - 2 = 0$

$-x = -0.94$ or $x = 0.94$

% of $Ni^{2+} = \dfrac{0.94}{0.98} \times 100 = 96\%$

$\therefore$ % of $Ni^{3+} = (100 - 96)\% = 4\%$

**(ii)** When ZnO is heated, it loses oxygen as :

$ZnO \xrightarrow{\text{Heat}} Zn^{2+} + \frac{1}{2}O_2 + 2e^-$

The $Zn^{2+}$ ions get trapped in the interstitial sites and electrons are trapped in the neighbouring interstitial sites to maintain electrical neutrality. This results in metal excess defect. Due to the presence of electrons in the interstitial void the colour is yellow.

**(iii)** Due to randomisation of spins at high temperature ferrimagnetic $Fe_3O_4$ becomes paramagnetic at 850 K.

OR

**(i) (a)** Due to small size of $Ag^+$ ion, it can fit into interstitial sites.

**(b)** Silicon doped with phosphorus forms *n*-type semiconductors whereas, silicon doped with gallium form *p*-type semiconductors.

**(ii)** Solids are incompressible as the constitutent particles of a solid are very closely packed and the intermolecular distances are very small. On applying high pressure on a solid, it will not compress rather it will deform.

**(iii)** Lattice point represents the constituent particles of a crystalline solid (as points). These constituent particles may be atoms, molecules or ions.

BRUSH UP

for

# NEET/JEE

CLASS-XI

Brush up your concepts to get high rank in NEET/JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests

2021

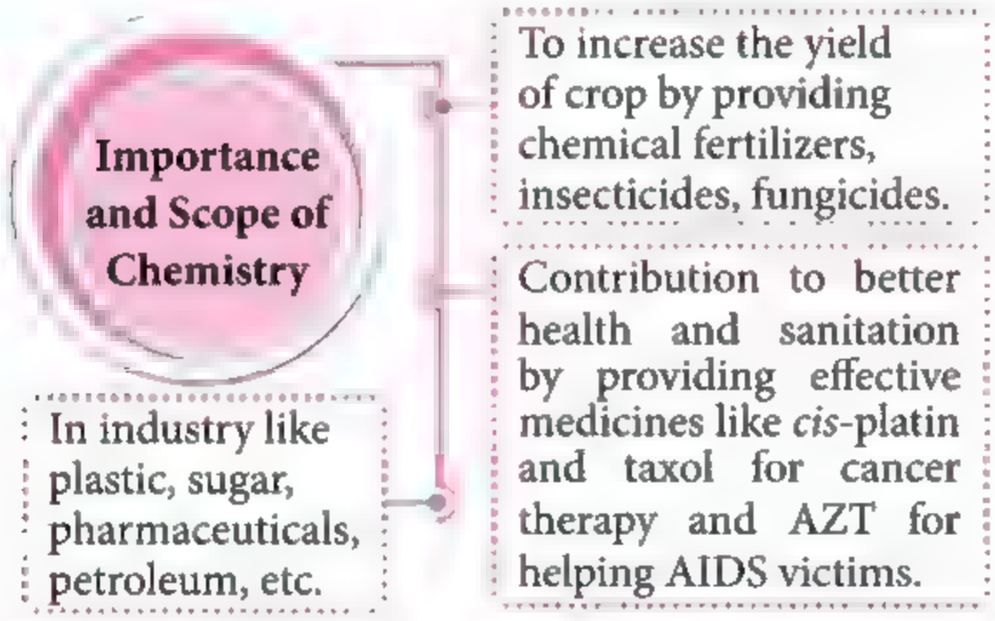
Unit 1

## Some Basic Concepts of Chemistry | Structure of Atom

### Some Basic Concepts of Chemistry

#### Introduction

- Chemistry is the branch of science which deals with the study of composition, structure and properties of matter and the changes which the matter undergoes under different conditions and the laws which govern these changes.




#### Physical Quantities and their Measurements

| Measure | Unit |
|---|---|
| Length ($l$) | Metre (m) |
| Mass ($m$) | Kilogram (kg) |
| Time ($t$) | Second (s) |
| Temperature ($T$) | Kelvin (K) |
| Electric current ($i$) | Ampere (A) |
| Intensity ($I_v$) | Candela (Cd) |
| Amount of substance ($n$) | Mole (mol) |

| Measure | Derivation |
|---|---|
| Volume ($V$) | Length × Height × Breadth $= m \times m \times m = m^3$ |
| Density ($d$) | $\frac{\text{Mass}}{\text{Volume}} = \frac{kg}{m^3} = kg\ m^{-3}$ |
| Velocity ($v$) | $\frac{\text{Distance}}{\text{Time}} = \frac{m}{s} = m\ s^{-1}$ |
| Force ($F$) | Mass × Acceleration $= m \times a$ $= kg\ m\ s^{-2}$ = Newton (N) |
| Work ($W$) | Force × Displacement $= F \times d$ $= kg\ m^2\ s^{-2}$ = Joule |
| Temperature ($T$) | $K = °C + 273.15$ |

#### Uncertainty in Measurement

##### Precision & Accuracy

- If the average value of different measurements is close to the correct value, the measurement is said to be accurate. If the value of different measurements are close to each other and hence close to their average value, the measurement is said to be precise.

## Significant Figures

- Significant figures in a number are all the certain digits plus one uncertain digit.

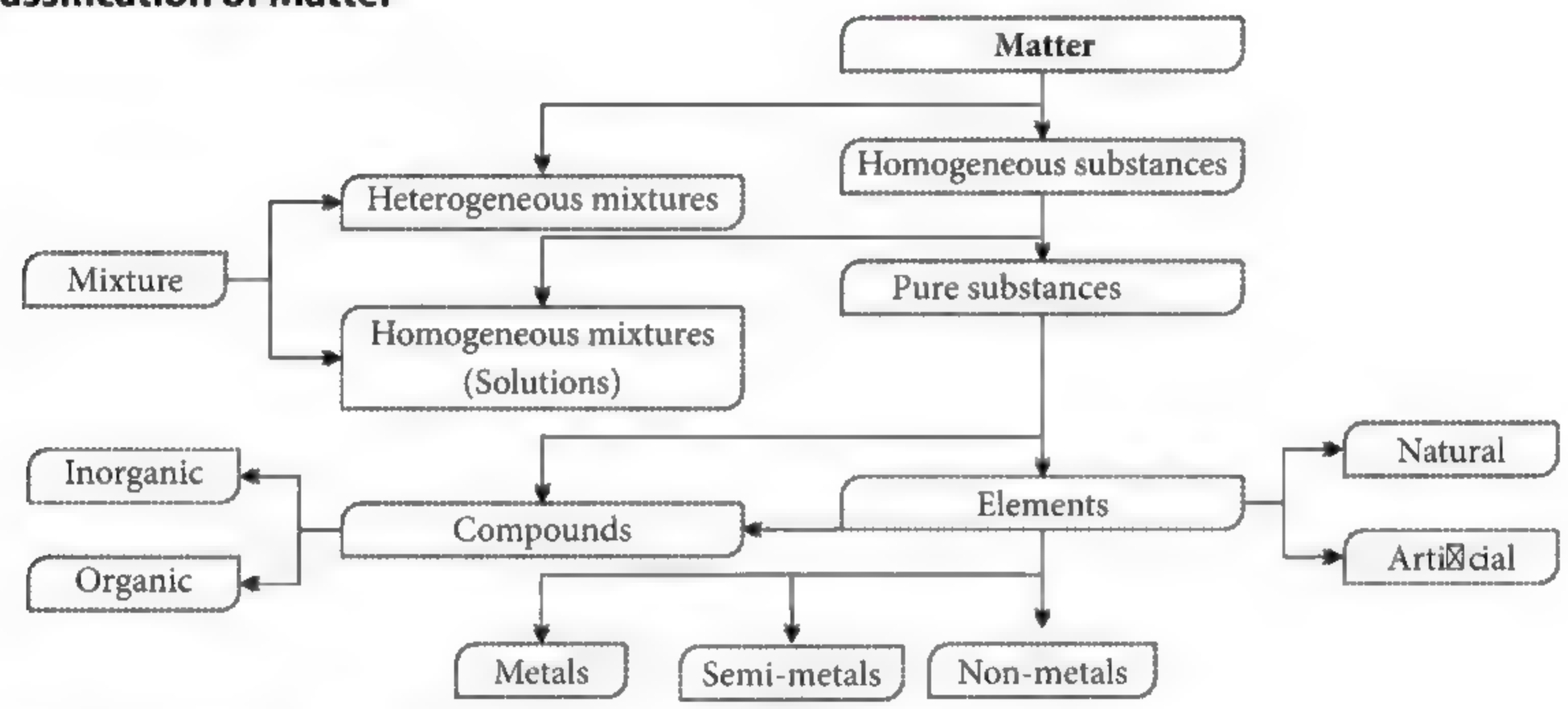
### Rules to determine significant numbers

- All non-zero digits as well as the zeros present between the non zero digits are significant.
- Zeros to the LHS of the first non-zero digit in a given number are not significant figures.
- In a number ending with zeros, if the zeros are present at right of the decimal point then these zeros are significant figures.
- Zeros at the end of a number without a decimal are not counted as significant figures.
- The result of division or multiplication must be reported to the same number of significant figures as possessed by the least precise term.
- The result of subtraction or addition must be reported to the same number of significant figures as possessed by the least precise term.

## Matter

- Anything which has mass and occupies space is known as matter.

## Classification of Matter




## Laws of Chemical Combinations

**Law of Conservation of Mass (*Lavoisier*)**
Matter can neither be created nor destroyed.

**Law of Constant Composition or Definite Proportions (*Proust*)**
A given compound always contains exactly the same proportion of elements by weight.

**Law of Multiple Proportions (*Dalton*)**
If two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in the ratio of small whole numbers.

**Laws of Chemical Combinations**

**Law of Reciprocal Proportions (*Richter*)**
The ratio of the masses of two elements *A* and *B* which combine separately with a fixed mass of the third element *C* is either the same or some simple multiple of the ratio of the masses in which *A* and *B* combine directly with each other.

**Gay Lussac's Law of Gaseous Volumes**
When gases combine or are produced in a chemical reaction they do so in a simple ratio by volume provided all gases are at same temperature and pressure.

**Avogadro's Law**
Equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

## Dalton's Atomic Theory

- All substances are made up of tiny, indivisible particles, called atoms. The word atom was derived from the Greek word atomos (meaning - indivisible.)
- Atoms cannot be created, divided or destroyed during any chemical or physical change (the law of conservation of mass.)
- Each element is composed of its own kind of atoms.
- The atoms of a given element are alike, and have the same mass. The atoms of different elements differ in mass and properties.
- The atoms combine with each other in simple whole number ratios to form a compound.

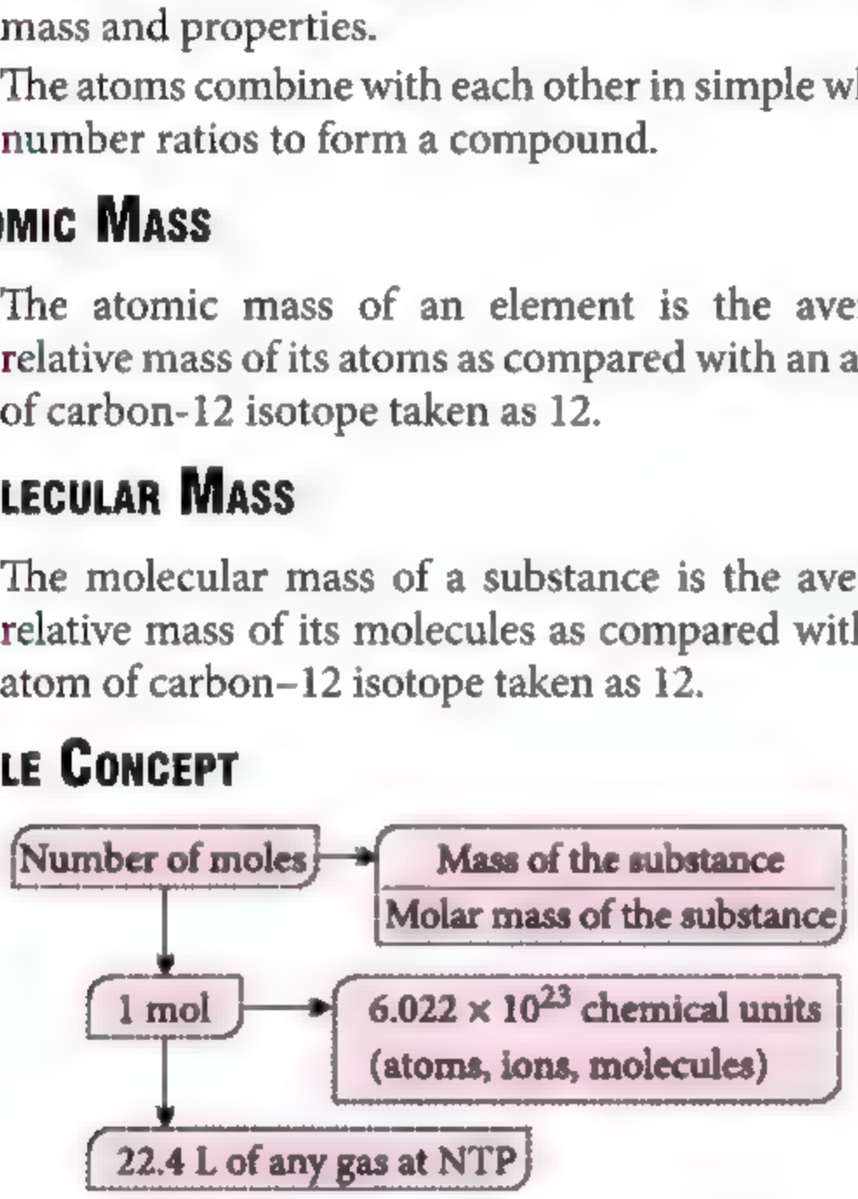
## Atomic Mass

- The atomic mass of an element is the average relative mass of its atoms as compared with an atom of carbon-12 isotope taken as 12.

## Molecular Mass

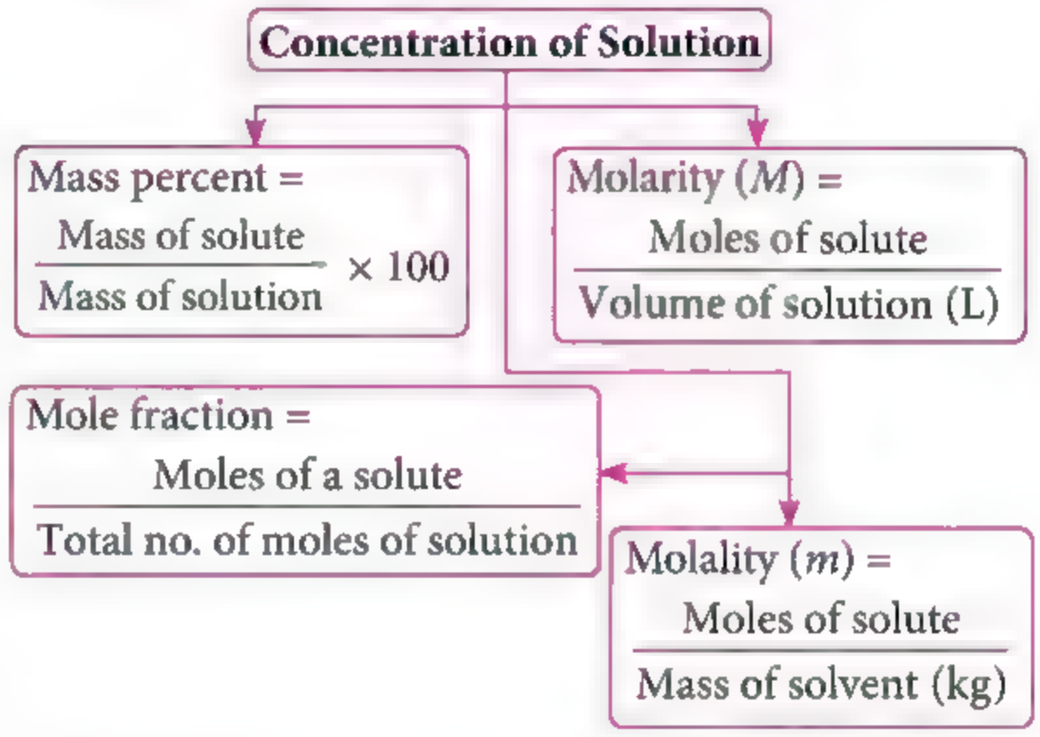
- The molecular mass of a substance is the average relative mass of its molecules as compared with an atom of carbon–12 isotope taken as 12.

## Mole Concept

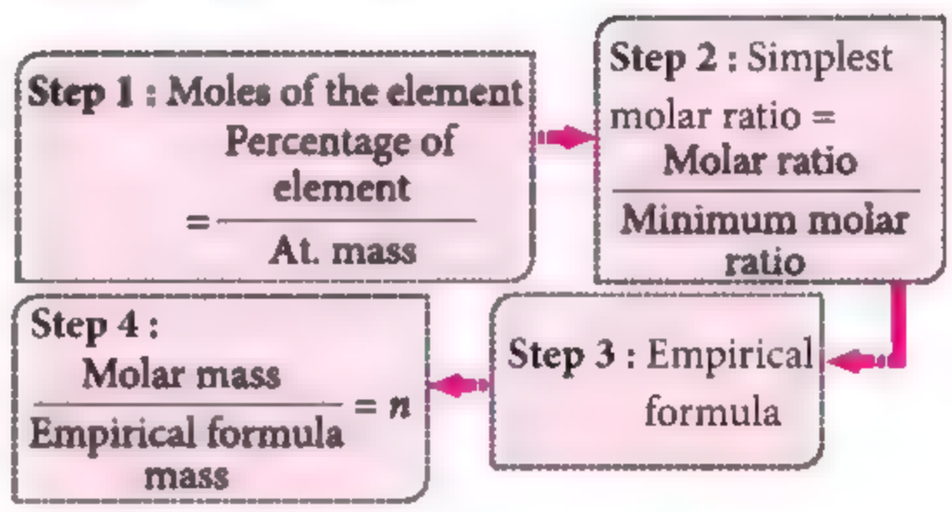



## Mole Concept in Solutions

- It is an expression to represent the amount of solute in a given quantity of solvent.




## Determination of Empirical Formula and Molecular Formula




Molecular formula = $n$ × Empirical formula

$n$ is integer such as 1, 2, 3 ... etc.

**Mass-energy conservation!**

The place where conservation of mass routinely falls down in nuclear fusion and fission, where large amounts of matter are converted to energy. Sunshine and starlight are the most visible examples. The sun converts about 5 million tons of mass to energy every second. In the process of fusing, 700 million tons of hydrogen convert to helium. It can go on at that rate for billions of years.

# Structure of Atom

## Sub-Atomic Particles

| | Electron ($e$) | Proton ($p$) | Neutron ($n$) |
|---|---|---|---|
| **Position** | Moves around the nucleus | Constituent of nucleus | Constituent of nucleus |
| **Charge** | $-1{\cdot}6 \times 10^{-19}$ C | $+1{\cdot}6 \times 10^{-19}$ C | neutral |
| **Absolute mass (kg)** | $9{\cdot}1 \times 10^{-31}$ | $1.67 \times 10^{-27}$ | $1.67 \times 10^{-27}$ |
| **Relative mass** | 1/1836 | 1 | 1 |
| **Discovery** | J. J. Thomson | E. Goldstein | J. Chadwick |

## Atomic Models

**Rutherford's Model**
The positive charge is concentrated in extremely small region called nucleus.
Electrons move around the nucleus in circular path called orbits.

**Thomson Model**
Atom is spherical, in which positive charge is uniformly distributed.
The electrons are embedded into it.

Atomic number ($Z$) = Number of protons ($p$) → Elements having same atomic number but different atomic mass are called isotopes.

Mass number ($A$) = No. of protons ($p$) + No. of neutrons ($n$) → Elements having same mass number but different atomic number are called isobars.

Number of neutrons ($n$) = $A - Z$ → Elements having same number of neutrons are called isotones.

Symbol of elements ${}^{A}_{Z}X$

## Developments Leading to the Bohr's Model of Atom

**Electromagnetic Radiations :**
J.C Maxwell proposed that light and other forms of radiations propagate through space in the form of waves. These waves have electric and magnetic fields associated with them and are therefore called electromagnetic radiations.

**Wavelength($\lambda$)**
Distance between two consecutive points.

**Frequency ($\upsilon$)**
$\upsilon = \frac{\text{velocity}}{\text{wavelength}}$

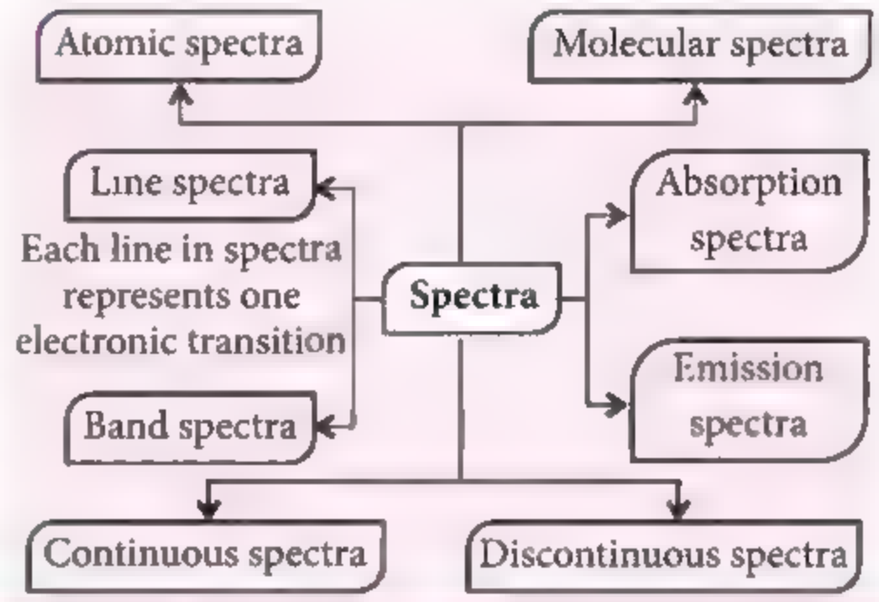
**Wave Number ($\bar{\upsilon}$)**
$\bar{\upsilon} = \frac{1}{\lambda}$

**Electromagnetic spectrum :** It is the arrangement of components of different types of electromagnetic radiations in increasing order of wavelength or decreasing order of frequency.

Cosmic rays | $\gamma$-rays | X-rays | UV | Visible | IR | Micro-waves | Radio-waves

Increasing wavelength or decreasing frequency

- Different types of spectra :




**Planck's Quantum Theory :**
- Definite amount of radiant energy is emitted or absorbed discontinuously in the form of small packets, called quanta.
- Amount of energy associated with quantum of radiation, is proportional to frequency of light *i.e.*

$E \propto \upsilon$, $E = h\upsilon$, $E = \frac{hc}{\lambda}$

$h$ = planck's constant ($6.626 \times 10^{-34}$ Js)

**Black Body Radiation**
An ideal body which emits and absorbs radiations of all wavelengths or frequencies.

**Photoelectric Effect**
When a beam of light of suitable wavelength falls on a clean metal plate in vacuum, electrons are emitted from the surface of metal. This phenomenon is known as photoelectric effect
$h\upsilon = h\upsilon_0 + 1/2\, mv^2$;
$h\upsilon_0$ = Minimum energy required to eject an electron = work function ($w$)

**INFO SHOTS**

**How old is hydrogen in our body!**
Every hydrogen in your body is likely to be 13.5 billion years old, since they were created during the birth of the universe. All the other elements formed by fusing hydrogen into helium, which then fused into carbon and so on.

## Atomic Spectra of Hydrogen

- Radiations emitted by hydrogen in discharge tube experiment when passed through prism gives six series of lines named after the researchers.

| | Name of series | Wavelength | $n_1$ | $n_2$ | Region |
|---|---|---|---|---|---|
| 1. | Lyman | $\frac{1}{\lambda}=R_H\left[\frac{1}{1^2}-\frac{1}{n^2}\right]$ | 1 | $n>1$ | UV |
| 2. | Balmer | $\frac{1}{\lambda}=R_H\left[\frac{1}{2^2}-\frac{1}{n^2}\right]$ | 2 | $n>2$ | Visible |
| 3. | Paschen | $\frac{1}{\lambda}=R_H\left[\frac{1}{3^2}-\frac{1}{n^2}\right]$ | 3 | $n>3$ | IR |
| 4. | Brackett | $\frac{1}{\lambda}=R_H\left[\frac{1}{4^2}-\frac{1}{n^2}\right]$ | 4 | $n>4$ | IR |
| 5. | Pfund | $\frac{1}{\lambda}=R_H\left[\frac{1}{5^2}-\frac{1}{n^2}\right]$ | 5 | $n>5$ | far IR |
| 6. | Humphrey | $\frac{1}{\lambda}=R_H\left[\frac{1}{6^2}-\frac{1}{n^2}\right]$ | 6 | $n>6$ | far-far IR |

- Rydberg formula : $\bar{\nu}=\frac{1}{\lambda}=R_H\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)Z^2$ where, $R_H$ is Rydberg constant and has a value equal to 109,677 $cm^{-1}$.

## Bohr's Atomic Model for Hydrogen

- Around the nucleus there are circular regions called orbits or shells.

| Energy shell | $K$ | $L$ | $M$ | $N$ | $O$.... |
|---|---|---|---|---|---|
| $n$ | 1 | 2 | 3 | 4 | 5.... |

Energy and distance from nucleus increase from $K$ onwards

- Every orbit has a fixed amount of energy so, it is also referred to as an energy level.
- An electron revolves around the nucleus without any loss of energy in a particular orbit of definite energy that is why orbit is called stationary state also.
- Angular momentum ($mvr$) in each orbit is quantised, $mvr=n\frac{h}{2\pi}=n\hbar$

  here, $h$ is Planck's constant.

| $n$ : | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| $mvr$ : | $\frac{h}{2\pi}$ | $\frac{h}{\pi}$ | $1.5\frac{h}{\pi}$ | $2\frac{h}{\pi}$ |

- When electron changes its orbit, energy change occurs in quanta.
  $\Delta E=E_2-E_1=h\upsilon$ or $=\frac{hc}{\lambda}$

  $E_2-E_1>E_3-E_2>E_4-E_3>E_5-E_4$ and so on.
- **Derived Formulae of Bohr's Theory (for $n^{th}$ orbit)**

| | For hydrogen | For H– like particles |
|---|---|---|
| Energy ($E_n$) | $\frac{-1312}{n^2}$ kJ/mol | $\frac{-1312\,Z^2}{n^2}$ kJ/mol |
| Radius ($r_n$) | $0.529\times n^2$ Å | $\frac{0.529\,n^2}{Z}$ Å |
| Speed ($v_n$) | $\frac{2.18\times10^8}{n}$ cm $s^{-1}$ | $\frac{2.18\times10^8}{n}\times Z$ cm $s^{-1}$ |

## Limitations of Bohr's Model

- Mathematically, Bohr's model explains only mono-electronic atoms and fails to explain repulsion in multielectronic atoms.
- It does not explain the distribution of electrons in orbits.
- It does not provide mathematical support to assumption, $mvr=n\times\frac{h}{2\pi}$
- It is against de Broglie and Heisenberg's principles.
- It does not explain the splitting of spectral lines under the influence of electric field (Stark effect) and magnetic field (Zeeman effect).

## Dual Nature of Radiation

- de Broglie has suggested that light can behave as a wave as well as like a particle. In 1924, de Broglie suggested that all microscopic particles such as electron, proton and atoms, etc. also have dual character.

  de Broglie wavelength, $\lambda=\frac{h}{mv}=\frac{h}{p}$
- Relation between Kinetic energy and wavelength,

$$\lambda=\frac{h}{\sqrt{2\times KE\times m}}$$

## Heisenberg's Uncertainty Principle

- According to this principle, it is impossible to determine simultaneously, the exact position and exact momentum (or velocity) of an electron. If the value of one is determined with certainty, the accuracy in determining the other value is compromised.

$$\Delta x.\Delta p \geq \frac{h}{4\pi}$$

$$\Delta x.m\Delta v \geq \frac{h}{4\pi}$$

Here, $\Delta x$ = uncertainty in position
$\Delta v$ = uncertainty in velocity

# Quantum Mechanical Model of Atom

## Schrodinger Wave Equation

$$\frac{d^2\psi}{dx^2}+\frac{d^2\psi}{dy^2}+\frac{d^2\psi}{dz^2}+\frac{8\pi^2 m}{h^2}(E-V)\psi=0$$

$\psi$ = amplitude of wave
$E$ = total energy of electron
$V$ = potential energy
$m$ = mass of electron

### Significance of $\psi$ and $\psi^2$

- $\psi$ : It has no physical significance. It represents amplitude of electron-wave or boundary surface of an orbital.
- $\psi^2$ : It is the probable electron density or it is the probability of finding electrons in any region (three dimensional space around the nucleus). If $\psi^2$ is positive, electrons are present and if $\psi^2$ is zero electrons are absent.

# Orbitals and Quantum Numbers

- **Orbital :** An orbital is a variably shaped, three dimensional region around the nucleus within which the probability of finding an electron is maximum.
- **Quantum numbers :** It is a set of four numbers which give complete information about all the electrons in an atom.

| Quantum Numbers | Values | Information Given |
|---|---|---|
| Principal quantum number | $n = 1, 2, 3 ...$ | • Energy of main shell.<br>• Maximum number of electrons present in $n^{th}$ shell = $2n^2$ |
| Azimuthal quantum number ($l$) | For a given value of $n$, $l = 0$ to $n - 1$.<br>For $s$ subshell, $l = 0$<br>For $p$ subshell, $l = 1$<br>For $d$ subshell, $l = 2$<br>For $f$ subshell, $l = 3$ | • It determines number of subshells.<br>• Shape of subshell.<br>• Angular momentum of the electron $= \sqrt{l(l+1)}\frac{h}{2\pi}$ |
| Magnetic quantum number ($m$ or $m_l$) | For a given value of $l$, $m = -l$ to $+l$ possible values of $m_l = (2l + 1)$ | • It determines number of orbitals present in one subshell = $(2l + 1)$.<br>• Number of orientations of each orbital. |
| Spin quantum number ($s$ or $m_s$) | $s = +\frac{1}{2}$ or $-\frac{1}{2}$ | • It tells about direction of electron spin, *i.e.*, clockwise or anticlockwise. |

**Node :** It represents the region where probability of finding an electron is zero, (*i.e.*, $\psi$ and $\psi^2 = 0$.)
Calculation of Nodes :

Node = $(n - 1)$

Radial nodes $(n - l - 1)$ | Angular nodes $l$

**Aufbau Principle :** The principle states that electrons are added progressively to the various orbitals in the order of increasing energies. The increasing order of energies of various orbitals is
*1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p 7s ...*

**Rules for Filling of orbitals**

**Hund's Rule :** This rule states that the pairing of electrons in the orbital of a particular subshell ($p$, $d$, or $f$) does not take place until all the orbitals of the subshell are singly filled.

**Pauli Exclusion Principle :** No two electrons in an atom can have the same set of four quantum numbers or only two electrons may exist in the same orbital and these electrons must have opposite spin.

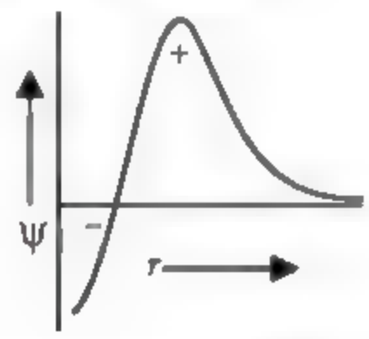
# WRAP it up!

1. How many moles of magnesium phosphate, $Mg_3(PO_4)_2$ will contain 0.25 mole of oxygen atoms?
(a) 0.02 (b) $3.125 \times 10^{-2}$
(c) $1.25 \times 10^{-2}$ (d) $2.5 \times 10^{-2}$

2. The radius of the second Bohr orbit for hydrogen atom is
(Planck's constant ($h$) = $6.6262 \times 10^{-34}$ J s;
mass of electron = $9.1091 \times 10^{-31}$ kg;
charge of electron = $1.60210 \times 10^{-19}$ C;
permittivity of vacuum
($\varepsilon_0$) = $8.854185 \times 10^{-12}$ $kg^{-1}$ $m^{-3}$ $A^2$)
(a) 0.529 Å (b) 2.12 Å
(c) 1.65 Å (d) 4.76 Å
**(JEE Main 2017)**

3. To neutralise completely 20 mL of 0.1 M aqueous solution of phosphorous acid, the volume of 0.1 M aqueous KOH solution required is
(a) 10 mL (b) 40 mL (c) 60 mL (d) 80 mL

4. Graph of wave function *vs* distance from the nucleus is given for an orbital :




The number of nodal sphere of this orbital is
(a) 1 (b) 2 (c) 3 (d) 4

5. Which one is the wrong statement?
(a) The uncertainty principle is $\Delta E \times \Delta t \geq \frac{h}{4\pi}$.
(b) Half filled and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement.
(c) The energy of 2*s*-orbital is less than the energy of 2*p*-orbital in case of hydrogen like atoms.
(d) de-Broglie's wavelength is given by $\lambda = \frac{h}{mv}$, where $m$ = mass of the particle, $v$ = group velocity of the particle.
**(NEET 2017)**

6. Energy of H-atom in the ground state is –13.6 eV, hence energy in the second excited state is
(a) –6.8 eV (b) –3.4 eV
(c) –1.51 eV (d) –4.53 eV

7. How many moles of ferric alum, $(NH_4)_2SO_4.Fe_2(SO_4)_3.24H_2O$ can be made from the sample of Fe containing 0.0056 g of it?
(a) $10^{-4}$ mol (b) $0.5 \times 10^{-4}$ mol
(c) $0.33 \times 10^{-4}$ mol (d) $2 \times 10^{-4}$ mol

8. An isotone of $^{76}_{32}Ge$ is
(i) $^{77}_{32}Ge$ (ii) $^{77}_{33}As$
(iii) $^{77}_{34}Se$ (iv) $^{78}_{34}Se$
(a) Only (i) and (ii) (b) Only (ii) and (iii)
(c) Only (ii) and (iv) (d) Only (ii), (iii) and (iv)

9. On analysis a certain compound was found to contain 254 g of iodine and 80 g of oxygen. The atomic mass of iodine is 127 and that of oxygen is 16. What is the formula of the compound?
(a) IO (b) $I_2O$ (c) $I_5O_2$ (d) $I_2O_5$

10. 1 gram of a carbonate ($M_2CO_3$) on treatment with excess HCl produces 0.01186 mole of $CO_2$. The molar mass of $M_2CO_3$ (in g $mol^{-1}$) is
(a) 118.6 (b) 11.86
(c) 1186 (d) 84.3
**(JEE Main 2017)**

11. Minimum number of photons of light of wavelength 4000 Å which provide 1 J energy is
(a) $2 \times 10^{18}$ (b) $2 \times 10^{9}$
(c) $2 \times 10^{20}$ (d) $2 \times 10^{10}$

12. The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is
(a) 40 (b) 10
(c) 20 (d) 30 **(NEET 2019)**

13. Arrange the electrons represented by the following set of quantum numbers in the decreasing order of energy
(i) $n = 4, l = 0, m = 0, s = +1/2$
(ii) $n = 3, l = 1, m = 1, s = -1/2$

(iii) $n = 3, l = 2, m = 0, s = +1/2$
(iv) $n = 3, l = 0, m = 0, s = -1/2$
(a) (i) > (ii) > (iii) > (iv)
(b) (iv) > (iii) > (ii) > (i)
(c) (iii) > (i) > (ii) > (iv)
(d) (i) > (iii) > (ii) > (iv)

**14.** Rutherford's experiment, which established the nuclear model of the atom, used a beam of
(a) β-particles, which impringed on a metal foil and got absorbed
(b) γ-rays, which impringed on a metal foil and ejected electrons
(c) helium atoms, which impringed on a metal foil and got scattered
(d) helium nuclei, which impinged on a metal foil and got scattered.

**15.** In compound *A*, 1.00 g nitrogen combines with 0.57 g oxygen. In compound *B*, 2.00 g nitrogen combines with 2.24 g oxygen. In compound *C*, 3.00 g nitrogen combines with 5.11 g oxygen. Which of the following laws is obeyed these results?
(a) Law of constant proportion
(b) Law of multiple proportion
(c) Law of reciprocal proportion
(d) Dalton's law of partial pressure

**16.** If Hund's rule is not followed, magnetic moment of $Fe^{2+}$, $Mn^{+}$ and Cr all having 24 electrons will be in order
(a) $Fe^{2+} < Mn^{+} < Cr$ (b) $Fe^{2+} = Cr < Mn^{+}$
(c) $Fe^{2+} = Mn^{+} < Cr$ (d) $Mn^{2+} = Cr < Fe^{2+}$

**17.** 3 g of activated charcoal was added to 50 mL of acetic acid solution (0.06 N) in a flask. After an hour, it was filtered and the strength of the filtrate was found to be 0.042 N. The amount of acetic acid adsorbed (per gram of charcoal) is
(a) 42 mg (b) 54 mg
(c) 18 mg (d) 36 mg
**(JEE Main 2015)**

**18.** The maximum probability of finding electron in the $d_{xy}$ orbital is
(a) along the *x*-axis (b) along the *y*-axis
(c) at an angle of 45° from the *x*- and *y*-axes
(d) at an angle of 90° from the *x*- and *y*-axes.

**19.** The angular momentum of an electron in a Bohr's orbit of H-atom is $4.2178 \times 10^{-34}$ kg $m^2 s^{-1}$. The wavelength of spectral line emitted when electron falls from this level to next lower level, is
(a) $1.0 \times 10^{-4}$ cm (b) $1.8 \times 10^{-4}$ cm
(c) $3.6 \times 10^{-4}$ cm (d) $5.4 \times 10^{-4}$ cm

**20.** Suppose the elements *X* and *Y* combine to form two compounds $XY_2$ and $X_3Y_2$. When 0.1 mole of $XY_2$ weighs 10 g and 0.05 mole of $X_3Y_2$ weighs 9 g, the atomic weights of *X* and *Y* are
(a) 40, 30 (b) 60, 40
(c) 20, 30 (d) 30, 20
**(NEET 2016 Phase-II)**

**21.** The molar masses of oxygen and sulphur dioxide are 32 and 64 respectively. If 1 L of oxygen at 25°C and 750 mm Hg pressure contains *N* molecules, then the number of molecules in 2 L sulphur dioxide under same conditions of temperature and pressure is
(a) $N/2$ (b) $3N/2$
(c) $2N$ (d) $6N$

**22.** If the shortest wavelength in Lyman series of hydrogen atom is *A*, then the longest wavelength in Paschen series of $He^{+}$ is
(a) $\frac{5A}{9}$ (b) $\frac{36A}{5}$
(c) $\frac{36A}{7}$ (d) $\frac{9A}{5}$
**(JEE Main Online 2017)**

**23.** The ratio of masses of oxygen and nitrogen in a particular gaseous mixture is 1 : 4. The ratio of number of their molecules is
(a) 3 : 16 (b) 1 : 4 (c) 7 : 32 (d) 1 : 8

**24.** 10 mL of 0.2 N HCl and 30 mL of 0.1 N HCl together exactly neutralise 40 mL of solution of NaOH, which is also exactly neutralised by a solution of 0.61 g of an organic acid in water. What is the equivalent weight of the organic acid?
(a) 61 (b) 91.5 (c) 122 (d) 183

**25.** Ejection of the photoelectron from metal in the photoelectric effect experiment can be stopped by applying 0.5 V when the radiation of 250 nm is used. The work function of the metal is
(a) 5 eV (b) 4 eV
(c) 5.5 eV (d) 4.5 eV
**(JEE Main Online 2018)**

**26.** For a precious stone, 'carat' is used for specifying its mass. If 1 carat = 3.168 grain (a unit of mass) and 1 gram = 15.4 grains. Find the total mass of the ring that contains a 0.500 carat diamond and 7.00 gram gold.

(a) 7.103 kg (b) $7.103 \times 10^{-3}$ kg

(c) $0.103 \times 10^{-3}$ kg (d) 0.103 kg

**27.** The number of radial and angular nodes in 3*p*-orbital are respectively

(a) 1, 0 (b) 2, 1 (c) 1, 1 (d) 2, 0

**28.** How many electrons can fit in the orbital for which $n = 3$ and $l = 1$?

(a) 2 (b) 6 (c) 10 (d) 14

**(NEET 2016 Phase-II)**

**29.** If $n = 6$, the correct sequence for filling of electrons will be

(a) $ns \rightarrow (n-2)f \rightarrow (n-1)d \rightarrow np$

(b) $ns \rightarrow (n-1)d \rightarrow (n-2)f \rightarrow np$

(c) $ns \rightarrow (n-2)f \rightarrow np \rightarrow (n-1)d$

(d) $ns \rightarrow np \rightarrow (n-1)d \rightarrow (n-2)f$

**30.** The result of the following calculation with the appropriate number of significant figures will be

$943 \times 0.00345 + 101$

(a) 104.2 (b) 104.253

(c) 104.25 (d) 104

## SOLUTIONS

**1. (b) :** 8 mol of O ≡ 1 mol $Mg_3(PO_4)_2$

$$0.25 \text{ mol O} = \frac{1 \times 0.25}{8} \text{ mol of } Mg_3(PO_4)_2$$

$$= 3.125 \times 10^{-2} \text{ mol of } Mg_3(PO_4)_2$$

**2. (b):** Radius of $n^{th}$ orbit for H-atom is

$$r = \frac{n^2 a_0}{Z} \text{ Å}$$

$$r = \frac{(2)^2 \times 0.529}{1} \text{ Å} \quad [\because n = 2, \text{ for second orbit}]$$

$r = 2.12$ Å

**3. (b):** $H_3PO_3$ is a dibasic acid (containing two ionisable protons attached to oxygen directly).

$H_3PO_3 \rightleftharpoons 2H^+ + HPO_4^{2-}$

0.1 M $H_3PO_3$ = 0.2 N $H_3PO_3$

0.1 M KOH = 0.1 N KOH

$N_1V_1 = N_2V_2$

(KOH) ($H_3PO_3$)

$0.1 \times V_1 = 0.2 \times 20$

$V_1 = 40$ mL

**4. (a)**

**5. (c) :** In case of hydrogen like atoms, energy depends on the principal quantum number only. Hence, 2*s*-orbital will have energy equal to 2*p*-orbital.

**6. (c) :** $E_n = \frac{-13.6}{n^2}$ eV

For second excited state $n = 3$,

$$E_3 = -\frac{13.6}{9} = -1.51 \text{ eV}$$

**7. (b):** Moles of Fe $= \frac{0.0056}{56} = 10^{-4}$

1 mol of alum = 2 mol of Fe

2 mol of Fe = 1 mol of alum

$$10^{-4} \text{ mol of Fe} = \frac{1}{2} \times 10^{-4} \text{ mol of alum}$$

$$= 0.5 \times 10^{-4} \text{ mol of alum}$$

**8. (c) :** Isotones have same number of neutrons.

$^{76}_{32}Ge : n = 76 - 32 = 44$

(i) $^{77}_{32}Ge : n = 77 - 32 = 45$

(ii) $^{77}_{33}As : n = 77 - 33 = 44$

(iii) $^{77}_{34}Se : n = 77 - 34 = 43$

(iv) $^{78}_{34}Se : n = 78 - 34 = 44$

**9. (d):** Mole of iodine $= \frac{254}{127} = 2$;

Mole of oxygen $= \frac{80}{16} = 5$

$\therefore$ Molecular formula of compound is $I_2O_5$.

**10. (d):** According to the question,

$M_2CO_3 + 2HCl \longrightarrow 2MCl + H_2O + CO_2$

In this equation, number of moles of $M_2CO_3$ is equal to that of $CO_2$.

*i.e.*, $n_{M_2CO_3} = n_{CO_2}$

$$\frac{\text{wt. of } M_2CO_3}{\text{molar mass of } M_2CO_3} = n_{CO_2}$$

$$\frac{1\text{g}}{\text{Molar mass of } M_2CO_3} = 0.01186 \text{ mol}$$

$$\text{Molar mass of } M_2CO_3 = \frac{1}{0.01186} \approx 84.3 \text{ g mol}^{-1}$$

**11. (a):** $E = nh\upsilon = \frac{nhc}{\lambda}$

$$1 = \frac{n \times 6.63 \times 10^{-34} \times 3 \times 10^{8}}{4000 \times 10^{-10}}$$

$n = 0.201 \times 10^{19} = 2.0 \times 10^{18}$

**12. (d):** Haber's process, $N_2 + 3H_2 \rightarrow 2NH_3$

2 moles of $NH_3$ are formed by 3 moles of $H_2$.

$\therefore$ 20 moles of $NH_3$ will be formed by 30 moles of $H_2$.

**13. (c):** The orbitals described by these sets of quantum numbers are :

(i) $4s$ (ii) $3p$ (iii) $3d$ (iv) $3s$

The energy of these orbitals follows the order :

$3d > 4s > 3p > 3s$

(iii) (i) (ii) (iv)

**14. (d):** Rutherford's experiment used a beam of $\alpha$-particles ($^4_2He$).

**15. (b)**

**16. (b):** If Hund's rule is not followed :

$Fe^{2+}$ : $[Ar]3d^6$; unpaired electrons = 0

$Mn^{+}$ : $[Ar]3d^5\ 4s^1$; unpaired electrons = 2

Cr : $[Ar]3d^4\ 4s^2$; unpaired electrons = 0

**17. (c):** No. of milliequivalents of acetic acid initially taken = (0.06 N) × (50 mL) = 3 meq

No. of milliequivalents of acetic acid left in the filtrate = (0.042 N) × (50 mL) = 2.1 meq

No. of milliequivalents of acetic acid adsorbed by activated charcoal = (3 – 2.1) = 0.9 meq

Amount of acetic acid adsorbed by 3 g of activated charcoal = 0.9 × 60 = 54 mg

Amount of acetic acid adsorbed by 1 g of activated charcoal = $\frac{54}{3} = 18$ mg

**18. (c):** $d_{xy}$ orbital lies at 45° angle in between $x$ and $y$-axes.

**19. (b):** According to Bohr's theory,

$$mvr = \frac{nh}{2\pi}$$

$$\frac{nh}{2\pi} = 4.2178 \times 10^{-34}$$

$$\text{or} \quad n = \frac{4.2178 \times 10^{-34} \times 2 \times 3.14}{6.625 \times 10^{-34}} = 4$$

Thus, electron falls from $n = 4$ level to $n = 3$ level.

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 109677 \times \left[\frac{1}{3^2} - \frac{1}{4^2}\right]$$

$\lambda \approx 1.8 \times 10^{-4}$ cm

**20. (a):** Let atomic weight of element $X$ be $x$ and that of element $Y$ be $y$.

For $XY_2$, $n = \frac{w}{\text{Mol. wt.}}$

$$0.1 = \frac{10}{x + 2y} \Rightarrow x + 2y = \frac{10}{0.1} = 100 \qquad ...(i)$$

For $X_3Y_2$, $n = \frac{w}{\text{Mol. wt.}}$

$$0.05 = \frac{9}{3x + 2y} \Rightarrow 3x + 2y = \frac{9}{0.05} = 180 \qquad ...(ii)$$

On solving equations (i) and (ii), we get $y = 30$

$x + 2(30) = 100 \Rightarrow x = 100 - 60 = 40$

**21. (c):** 1 L of oxygen at 25 °C and 750 mm Hg contains = $N$ molecules

$\therefore$ 2 L of oxygen at 25 °C and 750 mm Hg will contain = $2N$ molecules

$\therefore$ 2 L of sulphur dioxide at 25 °C and 750 mm Hg contains $2N$ molecules.

**22. (c):** The shortest wavelength of hydrogen atom in Lyman series is from $n_1 = 1$ to $n_2 = \infty$

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda_1} = \frac{1}{A} = R\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) = R$$

$\{\because Z = 1$, for hydrogen$\}$

$$\Rightarrow R = \frac{1}{A}$$

The longest wavelength in Paschen series of $He^+$ is from $n_1 = 3$ to $n_2 = 4$

$$\frac{1}{\lambda_2} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda_2} = \frac{1}{A}(2)^2\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = \frac{4}{A} \times \frac{7}{16 \times 9} = \frac{7}{36A}$$

$$\therefore \quad \lambda_2 = \frac{36A}{7}$$

**23. (c):** Ratio of masses of $O_2$ and $N_2$ = 1 : 4

Ratio of moles of $O_2$ and $N_2 = \frac{1}{32} : \frac{4}{28}$

= 7 : 32

$\therefore$ Ratio of molecules of $O_2$ and $N_2$ = 7 : 32

**24. (c) :** 10 mL of 0.2 N HCl + 30 mL of 0.1 N HCl ≡ 40 mL of NaOH (≡ 0.61 g of organic acid in water)

meq of HCl ≡ meq of NaOH ≡ meq of organic acid

$$10 \times 0.2 + 30 \times 0.1 \equiv \frac{0.61}{E} \times 1000$$

$$5 = \frac{0.61 \times 1000}{E}, \; E = \frac{610}{5} = 122$$

**25. (d):** $K.E. = h\upsilon - h\upsilon_0 = E - W_0$

where, $K.E.$ = Kinetic energy of ejected electron

= Stopping potential

$E$ = Energy absorbed

$W_0$ = Work function

$$E = h\upsilon = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{250 \times 10^{-9}}$$

$$= 7.9512 \times 10^{-19} \text{ J} = 4.96 \text{ eV}$$

Then, $0.5 = 4.96 + W_0$

$W_0 = 4.46 \approx 4.5$ eV

**26. (b):** Mass of diamond in the ring = 0.500 carat

$$0.500 \text{ carat} = 0.500 \text{ carat} \times \frac{3.168 \text{ grain}}{1 \text{ carat}}$$

$$= 1.584 \text{ grain} = \frac{1.584 \text{ grain}}{15.4 \text{ grain/g}} = 0.103 \text{ g}$$

So, total mass of the ring = 7.00 g + 0.103 g = 7.103 g

$= 7.103 \times 10^{-3}$ kg

**27. (c) :** Radial nodes = $n - l - 1 = 3 - 1 - 1 = 1$

Angular nodes = $l = 1$

**28. (a) :** For $n = 3$ and $l = 1$, the subshell is $3p$ and a particular $3p$ orbital can accommodate only 2 electrons.

**29. (a) :** For $n = 6$

$6s \rightarrow 4f \rightarrow 5d \rightarrow 6p$

**30. (d):** $943 \times 0.00345 = 3.25335 = 3.25$

As answer should be reported up to three significant numbers.

$3.25 + 101 = 104.25 = 104$

As answer should be reported to zero place of decimal.

# GET SET GO for JEE

Class XI

*with exclusive and brain storming MCQs*

Practicing these MCQs help to strengthen your concepts and give you extra edge in your JEE preparation

1. The angular velocity of an electron occupying the second Bohr orbit of $He^+$ ion is (in $sec^{-1}$)
   (a) $2.067 \times 10^{16}$ (b) $3.067 \times 10^{16}$
   (c) $1.067 \times 10^{18}$ (d) $2.067 \times 10^{17}$

2. 7 g of nitrogen is present at 127 °C and 16 g of oxygen at 27 °C. Calcualte the ratio of kinetic energy of nitrogen and oxygen.
   (a) 4 : 3 (b) 2 : 3 (c) 4 : 5 (d) 5 : 4

3. How many moles of $K_2Cr_2O_7$ can be reduced by 1 mole of $Sn^{2+}$ in acidic medium?
   (a) 2/3 (b) 1/6 (c) 1/3 (d) 1

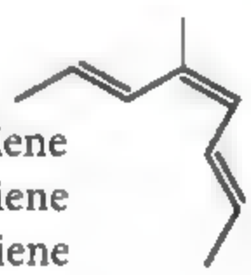
4. In a given energy level, the order of penetration effect of different orbitals is
   (a) $f < p < d < s$ (b) $s < p < d < f$
   (c) $f < d < p < s$ (d) $s = p = d = f$

5. 10 mL of 0.02 M $KMnO_4$ is required to oxidize 20 mL of oxalic acid of certain strength. 25 mL of the same oxalic acid is required to neutralize 20 mL of NaOH of unknown strength. Find the amount of NaOH in one litre of solution.
   (a) 2.5 (b) 1.5 (c) 4.0 (d) 1.25

6. In transforming 0.01 mole of PbS to $PbSO_4$, the volume of '10 volume $H_2O_2$' required will be
   (a) 11.2 mL (b) 22.4 mL
   (c) 33.6 mL (d) 44.8 mL

7. During change of $O_2$ to $O_2^-$ ion, the electron adds on which one of the following orbitals?
   (a) $\sigma^* 2p_z$ orbital (b) $\sigma\, 2p_z$ orbital
   (c) $\pi^* 2p_x / \pi^* 2p_y$ orbital (d) $\pi 2p_x / \pi 2p_y$ orbital

8. What is the correct IUPAC name of the following compound ?



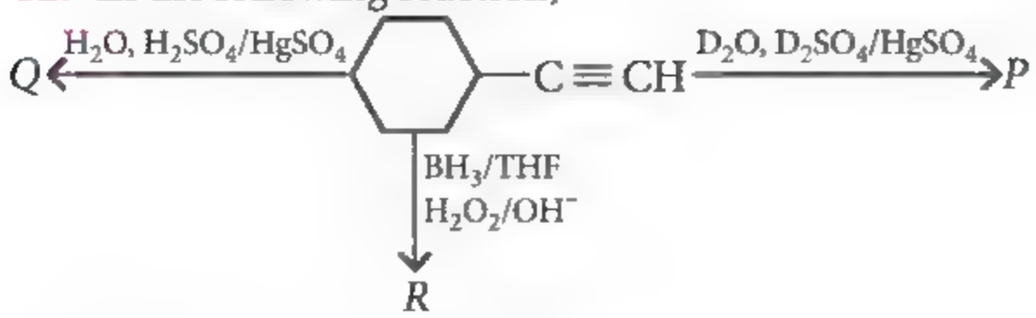
   (a) 2*E*, 4*E*, 6*Z* 4-methyloct-2, 4, 6-triene
   (b) 2*E*, 4*Z*, 6*Z* 5-methyloct-2, 4, 6-triene
   (c) 2*Z*, 4*Z*, 6*Z* 5-methyloct-2, 4, 6-triene
   (d) 2*E*, 4*Z*, 6*E* 4-methyloct-2, 4, 6-triene

9. The correct increasing order of *X*—O—*X* bond angle is (*X* = H, F or Cl)
   (a) $H_2O > Cl_2O > F_2O$ (b) $Cl_2O > H_2O > F_2O$
   (c) $F_2O > Cl_2O > H_2O$ (d) $F_2O > H_2O > Cl_2O$

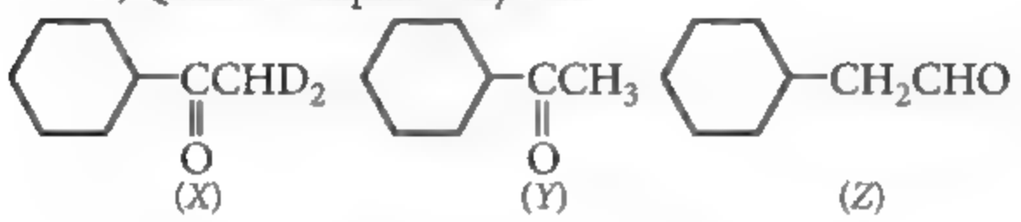
10. Calculate the extent of dissociation if the equilibrium pressure *P* for the system,
    $PCl_5 \rightleftharpoons PCl_3 + Cl_2$
    is numerically 3 times to its $K_p$.
    (a) 0.5 (b) 0.15 (c) 0.1 (d) 0.05

11. How can the given reaction is made to proceed in forward direction?
    $2B(OH)_3 + 2NaOH \rightleftharpoons NaBO_2 + Na[B(OH)_4] + 2H_2O$
    (a) Addition of *cis*-1, 2-diol
    (b) Addition of borax
    (c) Addition of *trans*-1, 2-diol
    (d) Addition of $Na_2HPO_4$

**12.** In the following reaction,




*P*, *Q* and *R* respectively are :




(a) *X*, *Y* and *Z* (b) *Y*, *X* and *Z*
(c) *Y* in all cases (d) *Z* in all cases.

**13.** In the following sequence of reactions :

$$Na_2CO_3 \xrightarrow[\text{Solution}]{SO_2} (A) \xrightarrow{Na_2CO_3} (B) \xrightarrow[\text{Heat}]{S} (C) \xrightarrow{AgNO_3} (D)$$

Identify the compounds (*A*), (*B*), (*C*) and (*D*).
(a) $Na_2SO_3$, $NaHSO_3$, $Na_2S$, $Ag_2S$
(b) $NaHSO_3$, $Na_2SO_3$, $Na_2S_2O_3$, $Ag_2S$
(c) $NaHSO_3$, $Na_2SO_4$, $Na_2S$, $Ag_2O$
(d) $Na_2SO_3$, $Na_2SO_4$, $Na_2S_2O_3$, Ag

**14.** For a perfectly crystalline solid $C_{p.m} = aT^3 + bT$, where *a* and *b* constant. If $C_{p.m}$ is 0.40 J/K mol at 10 K and 0.92 J/K mol 20 K, then molar entropy at 20 K is :
(a) 0.92 J/K mol (b) 8.66 J/K mol
(c) 0.813 J/K mol (d) 0.427 J/K mol

**15.** Frequent occurrence of water blooms in a lake indicates
(a) nutrient deficiency (b) oxygen deficiency
(c) excessive nutrient availability
(d) absence of herbivors in the lake.

## SOLUTIONS

**1.** **(a) :** Velocity of an electron in $He^+$ ion in an orbit ($\upsilon$)

$$= \frac{2\pi Ze^2}{nh} \quad ...(i)$$

Radius of $He^+$ ion in an orbit $(r_n) = \frac{n^2h^2}{4\pi^2me^2Z}$ ...(ii)

By equation (i) and (ii), we get

$$\text{Angular velocity } (\omega) = \frac{\upsilon}{r_n} = \frac{8\pi^3Z^2me^4}{n^3h^3}$$

$$= \frac{8\times(22/7)^3\times(2)^2\times(9.108\times10^{-28})\times(4.803\times10^{-10})^4}{(2)^3\times(6.626\times10^{-27})^3}$$

$$= 2.067\times10^{16}\ \text{sec}^{-1}$$

**2.** **(b) :** Kinetic energy $= \frac{3}{2}nRT$

For two gases, ratio of kinetic energies

$$= \frac{(K.E.)_1}{(K.E.)_2} = \frac{n_1T_1}{n_2T_2} = \frac{7}{28}\times400\times\frac{32}{16}\times\frac{1}{300} = 2:3$$

**3.** **(c) :** $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$$(Sn^{2+} \rightarrow Sn^{4+} + 2e^-)\times3$$

$$CrO_7^{2-} + 14H^+ + 3Sn^{2+} \rightarrow 3Sn^{4+} + 2Cr^{3+} + 7H_2O$$

It is clear from this equation that 3 moles of $Sn^{2+}$ reduce one mole of $Cr_2O_7^{2-}$, hence 1 mole $Sn^{2+}$ will reduce $\frac{1}{3}$ mole of $Cr_2O_7^{2-}$.

**4.** **(c) :** The order of penetration effect of different orbitals depends upon the different energies of the various sub-shells for the same energy level, *e.g.*, electrons in *s*-subshell will have lowest energy and thus will be closest to the nucleus and thus, have highest penetration power, while *p*-subshell electrons will penetrate the electron cloud to lesser extent and so on.

**5.** **(a) :** In acidic medium
1M $KMnO_4$ = 5 N $KMnO_4$
0.02 M $KMnO_4$ = 0.1 N $KMnO_4$
According to normality equation,
$N_1V_1$ ($KMnO_4$) = $N_2V_2$ (Oxalic acid)

$$0.1\times10 = N_2\times20 \Rightarrow N_2 = \frac{10\times0.1}{20} = 0.05\ \text{N}$$

Again, $N_1V_1$ (Oxalic acid) = $N_2V_2$ (NaOH)

$$0.05\times25 = N_2\times20$$

$$N_2 = \frac{0.05\times25}{20} = 0.0625\ \text{N}$$

Strength = Normality × equiv. wt.
$= 0.0625\times40 = 2.5\ \text{g L}^{-1}$

**6.** **(d) :** $PbS + 4H_2O_2 \longrightarrow PbSO_4 + 4H_2O$
0.01 mole 0 04 mole

$$4H_2O_2 \longrightarrow 4H_2O + 2O_2$$

0.04 mole 0.02 × 22400 mL at N.T.P.

Vol. of $O_2$ at N.T.P. = 0.02 × 22400 = 448 mL
∴ Volume of 10 volume $H_2O_2$ solution
= 448/10 = 44.8 mL

**7.** **(c) :** $O_2 \rightarrow [KK]\sigma2s^2\sigma^*2s^2\sigma2p_z^2\pi2p_x^2\pi2p_y^2\pi^*2p_x^1\pi^*2p_y^1$

$O_2^- \rightarrow [KK]\ \sigma2s^2\sigma^*2s^2\sigma2p_z^2\pi2p_x^2\pi2p_y^2\pi^*2p_x^2\pi^*2p_y^1$

As in $O_2$ HOMO is $\pi^*2p_x$ and $\pi^*2p_y$ and they have one electron each so next electron can be added to any of these orbitals.

**8.** **(d) :** Higher priority groups same side $\Rightarrow$ *Z* – form
Higher priority groups opposite side $\Rightarrow$ *E* – form

**9.** **(b) :** Cl—O—Cl bond angle is more due to large size of Cl and F—O—F bond angle is least due to bent structure.

**10.** **(a) :**

| | $PCl_5 \rightleftharpoons$ | $PCl_3$ | + | $Cl_2$ |
|---|---|---|---|---|
| Initial | 1 | 0 | | 0 |
| At equil. | 1–*x* | *x* | | *x* |

Total moles at equilibrium (if *x* is extent of dissociation) = $1 - x + x + x = 1 + x$

Partial pressure of $PCl_5 = \frac{1-x}{1+x}P$

Similarly, partial pressures of $PCl_3$ and $Cl_2$,

$\left(p_{PCl_3} = \frac{x}{1+x}P\right)$ and $p_{Cl_2} = \frac{x}{1+x}P$

Equilibrium constant, $K_p = \frac{(p_{PCl_3})(p_{Cl_2})}{(p_{PCl_5})}$

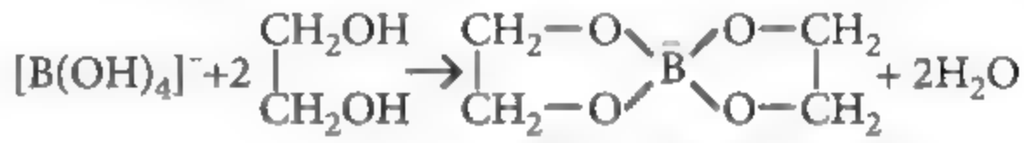
Substituting the values,

$$K_p = \frac{\left(\frac{xP}{1+x}\right)\left(\frac{xP}{1+x}\right)}{\frac{(1-x)P}{1+x}} = \frac{x^2P}{1-x^2}$$

$$\frac{P}{3} = \frac{x^2P}{1-x^2} \text{ or } x^2 = \frac{1}{4} \Rightarrow x = \frac{1}{2}$$

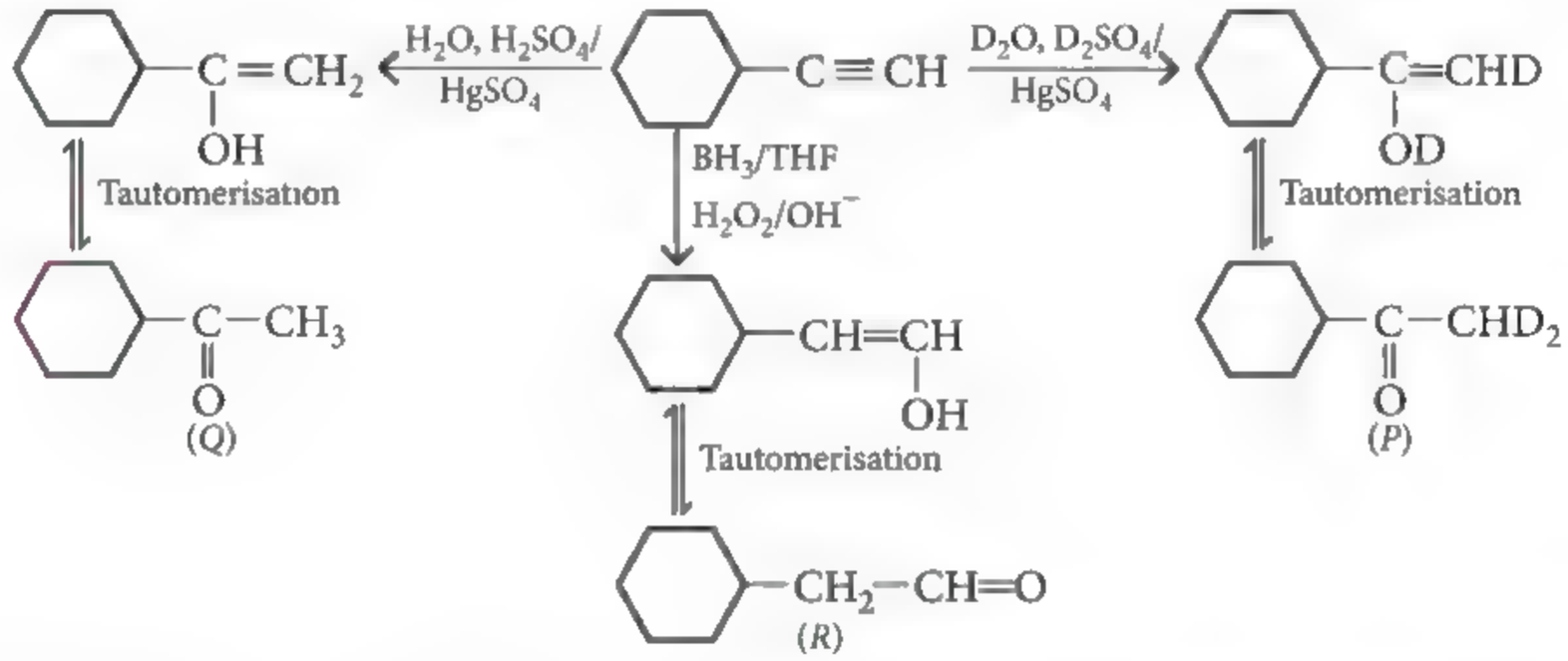
$\therefore$ Extent of dissociation of $PCl_5 = 0.5$

**11.** **(a) :** Orthoboric acid ($H_3BO_3$) is a weak monobasic acid due to $p\pi$-$p\pi$ back bonding between B and O. Direct neutralisation with alkali is not complete. In the presence of *cis*-1, 2-diol, a stable complex is formed and reaction goes to completion.




Chelate complex compound

**12.** **(a) :**




**13.** **(b) :** $Na_2CO_3 + 2SO_2 + H_2O \longrightarrow \underset{(A)}{2NaHSO_3} + CO_2$

$\underset{(A)}{2NaHSO_3} + Na_2CO_3 \longrightarrow \underset{(B)}{2Na_2SO_3} + H_2O + CO_2$

$\underset{(B)}{Na_2SO_3} + S \xrightarrow{\text{Heat}} \underset{(C)}{Na_2S_2O_3}$

$\underset{(C)}{Na_2S_2O_3} + AgNO_3 \longrightarrow \underset{(D)}{Ag_2S} + H_2SO_4$

**14.** **(d) :** $0.40 = aT_1^3 + bT_1$

$\Rightarrow \quad 0.4 = 1000a + 10b$ ...(i)

$0.92 = aT_2^3 + bT_2$

$\Rightarrow \quad 0.92 = a \times 8000 + 20b$ ...(ii)

from Eqs. (i) and (ii), we get

$a = 2 \times 10^{-5}, b = 0.038$

$$S_m = \int \frac{aT^3 + bT}{T}.dT = \frac{a[T_2^3 - T_1^3]}{3} + b[T_2 - T_1]$$

= 0.427 J/K mol

**15.** **(b) :** In polluted water, nitrogen and phosphorus (from sewage) are accumulated which results in excessive growth of algae on water surface. Excessive growth of algae called water bloom. Due to death and decomposition of organic matter, $O_2$ is not available to aquatic animals.

**Monthly Test Drive CLASS XII** **ANSWER KEY**

| | | | | |
|---|---|---|---|---|
| **1.** (a) | **2.** (d) | **3.** (d) | **4.** (d) | **5.** (c) |
| **6.** (b) | **7.** (b) | **8.** (d) | **9.** (c) | **10.** (c) |
| **11.** (a) | **12.** (b) | **13.** (d) | **14.** (d) | **15.** (a) |
| **16.** (b) | **17.** (d) | **18.** (b) | **19.** (c) | **20.** (a,b,c) |
| **21.** (b,d) | **22.** (b,c,d) | **23.** (a,b,c) | **24.** (4) | **25.** (5) |
| **26.** (6) | **27.** (c) | **28.** (c) | **29.** (a) | **30.** (a) |

# MONTHLY TEST DRIVE

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

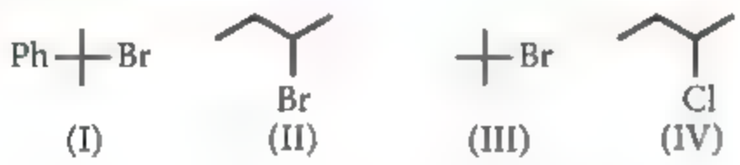
## Organic Chemistry-Some Basic Principles and Techniques

Time Taken : 60 Min.

**NEET**

### Only One Option Correct Type

1. Arrange these compounds in the order of increasing rate of $S_N1$ reaction.

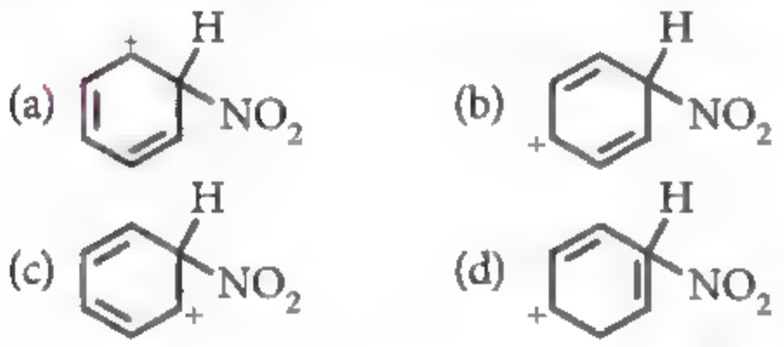


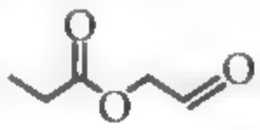

(I) (II) (III) (IV)

(a) IV < II < III < I (b) I < II < III < IV
(c) IV < I < III < II (d) IV < I < II < III

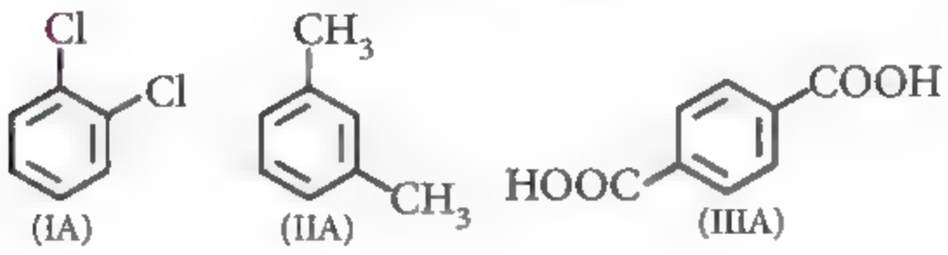
2. Tautomerism is exhibited by
(a) $(CH_3)_3CNO$ (b) $(CH_3)_2NH$
(c) $R_3CNO_2$ (d) $RCH_2NO_2$

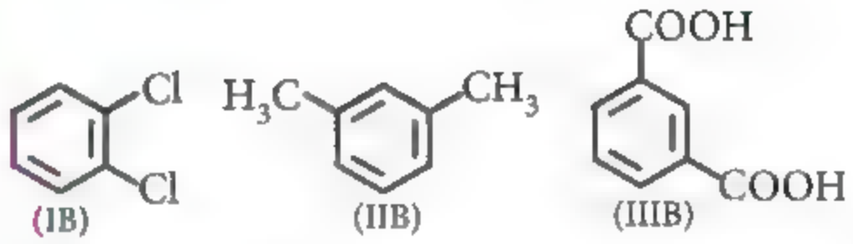
3. Which is not the resonance structure of a carbocation?




4. The IUPAC name of the compound  is
(a) 2-formylmethyl propanoate
(b) 2-oxoethyl propanoate
(c) 2-propionyloxyethanal
(d) both (a) and (b) are correct.

5. Consider the following pairs of possible isomers




Which of the following statements is correct?
(a) All three pairs represent different compounds.
(b) IA and IB are identical; IIA and IIB are identical; and IIIA and IIIB are identical.
(c) IA and IB are isomers; IIA and IIB are identical; and IIIA and IIIB are isomers.
(d) IA and IB are identical; IIA and IIB are identical, and IIIA and IIIB are isomers.

6. The Lassaigne's extract of an organic compound after acidification with $HNO_3$ is mixed with a few mL of $CCl_4$ and then treated with chlorine water. The lower layer of $CCl_4$ develops a violet colour. This indicates that the organic compound contains
(a) nitrogen (b) sulphur
(c) bromine (d) iodine.

7. Which one of the following has all the effects, namely inductive, mesomeric and hyperconjugative?
(a) $CH_3Cl$ (b) $CH_3CH{=}CH_2$
(c) $CH_3CH{=}CHC(=O)CH_3$ (d) $CH_2{=}CH{-}CH{=}CH_2$

8. The number of isomers (geometrical and optical) possible for the compound with the following structure
$CH_3CH{=}CH{-}CH{=}CH{-}CH_2CHOHCH_3$ is
(a) 2 (b) 4 (c) 6 (d) 8

9. The correct order of reactivity for the following compounds in $S_N2$ reaction : $CH_3Cl$, $CH_3CH_2Cl$, $(CH_3)_2CHCl$ and $(CH_3)_3CCl$ is
   (a) $CH_3Cl > (CH_3)_2CHCl > CH_3CH_2Cl > (CH_3)_3CCl$
   (b) $CH_3Cl > CH_3CH_2Cl > (CH_3)_2CHCl > (CH_3)_3CCl$
   (c) $CH_3CH_2Cl > CH_3Cl > (CH_3)_2CHCl > (CH_3)_3CCl$
   (d) $(CH_3)_2CHCl > CH_3CH_2Cl > CH_3Cl > (CH_3)_3CCl$

10. For the detection of phosphorus, the organic compound after fusion with $Na_2O_2$ is extracted with water, boiled with $HNO_3$ and then ammonium molybdate is added to it. A yellow ppt. is obtained which is due to the formation of
   (a) ammonium phosphate
   (b) ammonium phosphomolybdate
   (c) ferric phosphate
   (d) disodium ammonium phosphate.

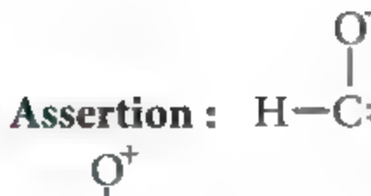
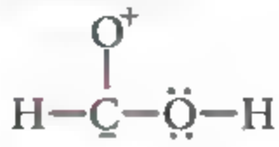
11. In E2 elimination, some compounds follow Hofmann's rule which means
   (a) the double bond goes to the most substituted position
   (b) the compound is resistant to elimination
   (c) no double bond is formed
   (d) the double bond goes mainly towards the least substituted carbon.

12. The empirical formula of a compound is $CH_2$. The mass of one mole of the compound is 42 g. Therefore, its structural formula is
   (a) $CH_3CH_2CH_3$
   (b) $CH_3—CH=CH_2$
   (c) $CH_2=CH—CH=CH_2$
   (d) $CH_3—C\equiv CH$

### Assertion & Reason Type

**Directions :** In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** The central carbon atom in $H_2C=C=CH_2$ is *sp*-hybridised.
   **Reason :** In this molecule all the carbon atoms are attached to each other by double bonds.

14. **Assertion :**  is more stable than 
   **Reason :** Compound in which the positive and negative charges reside on the most electropositive and most electronegative atoms of the species respectively is more stable.

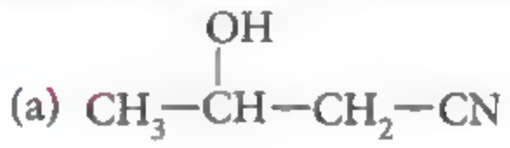
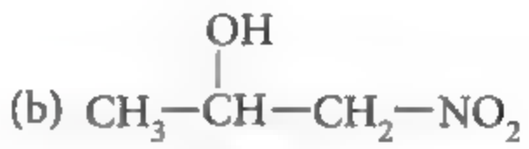
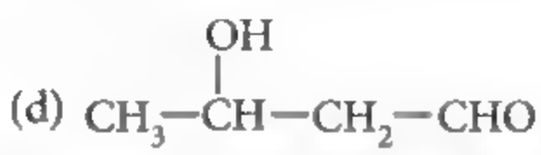
15. **Assertion :** The IUPAC name for the compound, $NCCH_2CH_2COOH$ is 4-carboxybutanenitrile.
   **Reason :** —COOH is considered as substituent group while —CN is considered as the principal functional group.

**JEE MAIN / JEE ADVANCED**

### Only One Option Correct Type

16. Dichlorocarbene is generated by the action of potassium-1-butoxide on chloroform. This is an example of
   (a) α-elimination reaction
   (b) β-elimination reaction
   (c) addition reaction
   (d) rearrangement reaction.

17. In the following groups
   (I) – OAc (II) –OMe
   (III) – $OSO_2Me$ (IV) – $OSO_2CF_3$
   the order of leaving group ability is
   (a) I > II > III > IV (b) IV > III > I > II
   (c) III > II > I > IV (d) II > III > IV > I

18. Which alcohol will be most reactive for dehydration?
   (a) 
   (b) 
   (c) 
   (d) 

19. In the anion $HCOO^-$ the two carbon-oxygen bonds are found to be of equal length. What is the reason for it?
   (a) The C=O bond is weaker than the C—O bond.
   (b) The anion $HCOO^-$ has two resonating structures.

(c) The anion is obtained by removal of a proton from the acid molecule.
(d) Electronic orbitals of carbon atom are hybridised.

**More than One Options Correct Type**

**20.** Reaction between neopentyl bromide and ethanol gives 2-methoxy-2-methyl butane as the major products because
(a) this involves a 1, 2-hydride shift
(b) this involves a 1, 2-alkyl shift
(c) this occurs through a $S_N1$ mechanism
(d) this is also accompanied with the formation of alkenes as by product.

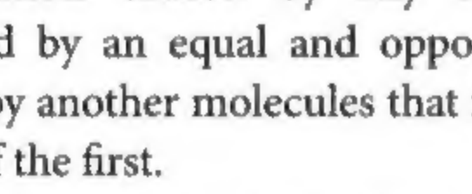
**21.** Br has a low reactivity in $CH_2 = CH—Br$ because
(a) Br is electronegative
(b) of the $+M$ effect of bromine
(c) the C—Br bond has a partial double bond character
(d) Br shows $+I$ effect.

**22.** Which of the following species are planar?
(a) *Iso*-propyl carbanion
(b) Nitromethyl carbanion
(c) Singlet carbene
(d) Triphenylmethyl carbocation

**23.** Which of the following statements are correct?
(a) A *meso* compound is optically active because the rotation caused by any molecules is cancelled by an equal and opposite rotation caused by another molecules that is the mirror image of the first.
(b) A *meso* compound has chiral centres but exhibits no optical activity.
(c) A *meso* compound has a plane of symmetry and thus exhibits no optical activity.
(d) A *meso* compound has molecules which are superimposable on their mirror image even though they contain chiral centres.

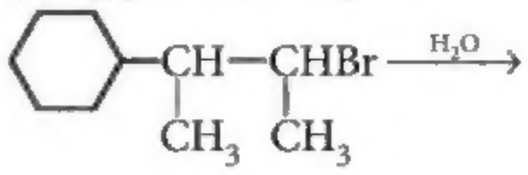
**Numerical Value Type**

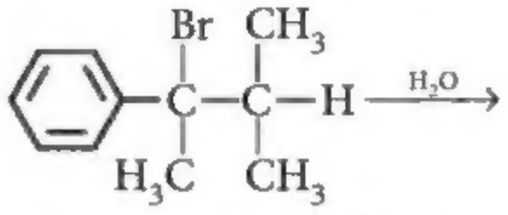
**24.** On bromination of the following compound, Br goes to which position in the major product?




**25.** How many of the following $S_N$ reactions will give product by rearrangement?

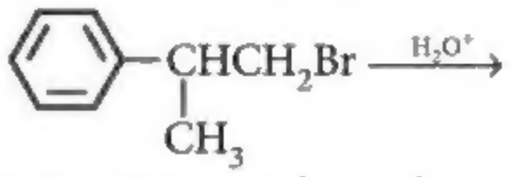
I. $(CH_3)_3C—Cl + H_2O \rightarrow$

II. 


III. 


IV. $(CH_3)_2CHCH_2Br \xrightarrow{H_2O/Ag^+}$

V. $(CH_3)_3CCH_2Br \xrightarrow{H_2O/Ag^+}$

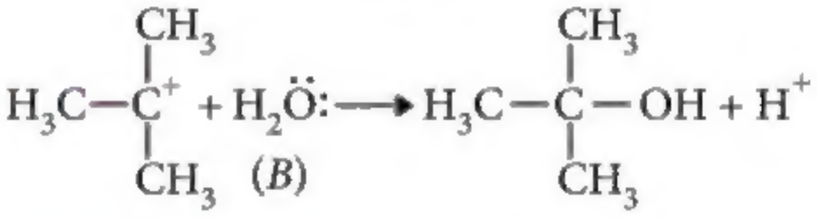
VI. 


**26.** A conjugate system has at least ..... $\pi$ electrons.

**Comprehension Type**

The reaction of an electrophile with a nucleophile is the same as the reaction of a Lewis acid with a Lewis base and is termed as Lewis acid-base association reaction, as a result of which each atom in the product completes its octet (except H which completes its duplet).

**27.** Consider the following reaction between an electrophile and nucleophile,



Incorrect statement (s) is/are

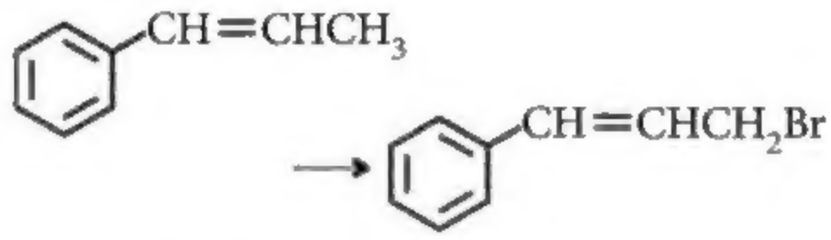
(a) It is a Lewis acid-base association reaction.

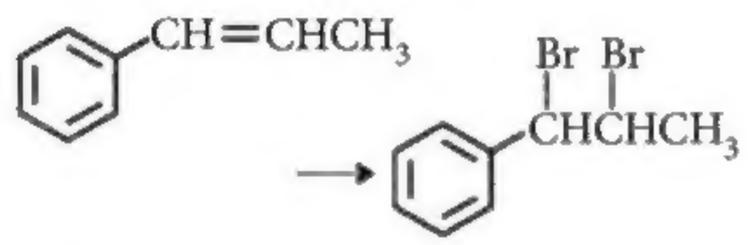
(b) It is a Lowry-Bronsted acid-base reaction.

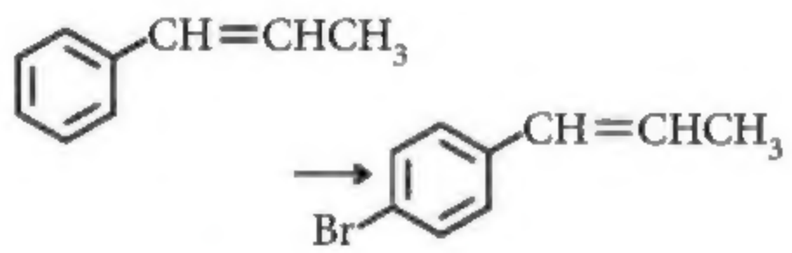
(c) Driving force that makes $\Delta G$ negative is the completion of the octet of C and O atoms in the product.

(d) *A* is an electrophile and *B* is a nucleophile.

**28.** In which case additional reagent is required to generate an electrophile?

(a) 

(b) 

(c) 

(d) In all cases

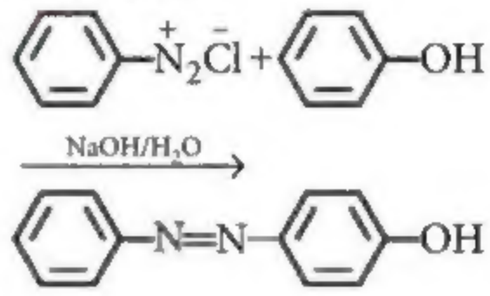
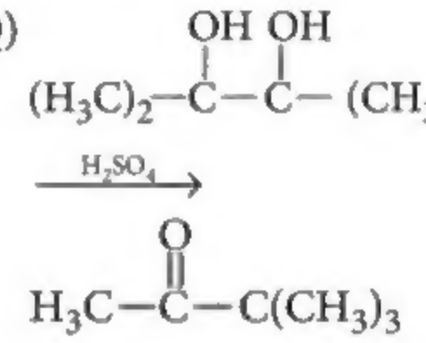
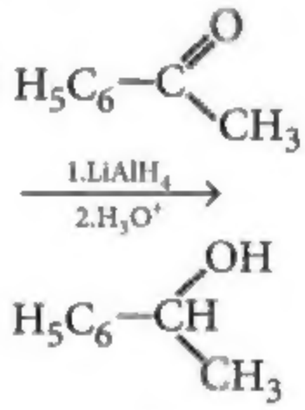
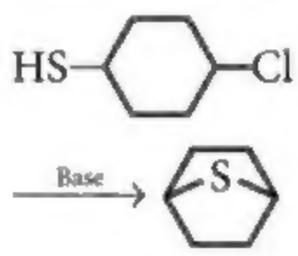
## Matrix Match Type

**29.** Match the entries listed in Column I with appropriate entries listed in Column II.

| Column I | Column II |
|---|---|
| (P) 1, 2-Dichloroethane | 1. Gauche conformation |
| (Q) 1, 2-Dimethyl-cyclopropane | 2. Geometrical isomerism |
| (R) 1, 2-Ethanediol | 3. Chair conformation |
| (S) 1, 2-Dimethyl-cyclohexane | 4. Conformational isomerism |

| | P | Q | R | S |
|---|---|---|---|---|
| (a) | 1,2 | 2,4 | 3 | 2 |
| (b) | 2, 4 | 3, 1 | 1, 2 | 4 |
| (c) | 4 | 2 | 1, 4 | 2, 3, 4 |
| (d) | 1, 3, 4 | 2, 3 | 3, 4 | 1, 2 |

**30.** Match the reaction in Column I with appropriate options in Column II.

| Column I | Column II |
|---|---|
| (P)  | 1. Racemic mixture |
| (Q)  | 2. Addition reaction |
| (R)  | 3. Substitution reaction |
| (S)  | 4. Coupling reaction |
| | 5. Carbocation intermediate |

| | P | Q | R | S |
|---|---|---|---|---|
| (a) | 3, 2 | 5, 1 | 1, 3 | 2 |
| (b) | 2, 4 | 5, 3 | 3 | 4 |
| (c) | 3, 4 | 5 | 1, 2 | 3 |
| (d) | 4, 5 | 1,4 | 3, 2 | 1 |

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No. of questions attempted .....

No. of questions correct .....

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| | | |
|---|---|---|
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| 90-75% | GOOD WORK ! | You can score good in the final exam. |
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